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THE POSITION OF AGRICULTURE IN THE ECONOMIC LIFE OF CANADA

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The object of this article is to consider the relative importance of agriculture in Canada and the special problem of Canadian agriculture in depression. It has no intention of reviving the hackneyed and futile argument regarding the relative importance of agriculture and industry nor to insist on the Physiocratic notion that the land and the farmers are all-important. Industrial and agricultural endeavours are clearly inter-dependent, but the position of industry is intensively advertised and well understood, while agriculture sits quietly at home and is generally regarded as the Cinderella in the national family. As the late Sir Horace Plunkett once said: "So little thought has been given—and even now is given—to the rural side of things."

Canada has an area of about 350 million acres of land suitable for farming purposes. Of this total, 163¼ million acres are in occupied farms, of which nearly 86 million acres are improved land. Even at the low valuations existing in June, 1932, farm land was valued at $1,948,070,000. Buildings on farms represented a further investment of $1,342,924,000 at 1932 valuations. These figures indicate the extent of our investment in agriculture, an industry which supports nearly five million of our population directly, and many others indirectly through farm purchasing power.

During the present period of depression it has become even more evident that agriculture has a very important place in the determination of our economic stability. As long as farm production and prices are normal, the farmer's purchasing power is an important influence in keeping manufacturing, transportation and distribution interests in profitable operation. As the world sinks into depression, commodity prices decline. The prices of staple farm products generally begin the movement and carry it the greatest distance. The other cost items such as wages, taxes, mortgage rates, equipment prices, and transportation charges lag behind on the downward trend. Naturally, retail and wholesale prices—which include many of these costs in high proportion—decline less slowly. Thus the stimulating effects of low prices on consumption are not quickly felt, as prices to consumers do not fall at nearly the same rate nor to the same extent as producers' prices. Demand, therefore, is further affected and the decline in the prices of farm products accentuated.

The individual farmer's net income is small—his annual cash receipts are, even in good times, dangerously close to the sum of fixed charges, such as taxes and mortgage and machinery debts. That this is true is indicated by the fact that only a mere handful of farmers pay federal income tax.

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World depression soon strikes the farmer and deprives him of his surplus purchasing power to the almost immediate detriment of the country's economy. Industrial occupations are directly affected by the reduced ability of farmers to pay for consumption goods.

Farm Expenses

The census of 1931 reveals the following expenditures by farmers in 1930:

Labour	$100,425,980
Taxes	54,134,640
Feed	47,283,610
Farm machinery	31,522,200
Fertilizer	8,121,730
Light and Power	2,377,980

These expenses alone amount to about 244 million dollars and are by no means complete. The annual charges on farm mortgages are in the neighborhood of 50 million dollars, with no allowance for repayment of principal. Many other necessary expenses demand large outlays. About 25 to 30 million dollars are spent in cash for seeds. The census showed that at June 1, 1931, there were 105,269 tractors, 178,714 gasoline engines, 321,276 automobiles and 48,402 motor trucks on Canadian farms. All these machines require gasoline, oil and repairs and are in need of periodic replacement. Many farmers are carrying debts for farm machinery incurred in past years and the interest and principal involved are considerable. Expenditures for licenses of farm automobiles amount to several millions of dollars. Lumber and hardware constitute important expense items, especially in good times. Supplies such as binder twine, sacks, fruit boxes, etc., demand large outlays. The Canadian farm consumption of binder twine averages over 60 million pounds a year. Insurance is another item. The payments for consumption goods and for other services, such as medical and veterinary care, constitute very important factors in farm expenditure. Using the data of the census of agriculture and of the census of merchandising and service establishments as far as possible and estimating where necessary, it is calculated that the Canadian farm population spent 557 million dollars in 1930 for these above-mentioned items, apart from food and clothing. Food and apparel would account for at least 325 million and 75 million dollars respectively. The total estimate of 957 million dollars amounts to 75% of the gross agricultural revenue of 1930; it represents over $1300 per farm and $177 per rural inhabitant. In total, the large amount represented emphasizes the financial power of the farming population and shows how vital is the need for its maintenance on a remunerative basis in the promotion of national prosperity.

Industries and Other Interests Dependent Upon Agriculture

Farm production forms the basis of many of our great *manufacturing and processing industries* to an extent which is not generally appreciated. In 1931 (the last year for which complete statistics are available) 9,298 establishments were engaged in manufacturing products of farm origin. Of this number, only 327 firms were working with foreign agricultural products, principally rubber, cotton, sugar and coffee. The establishments using Canadian agricultural products (8,971) reported a capital of $676,422,157, employees numbering 123,076, salaries and wages of $123,027,130, and a gross

value of products amounting to $761,077,995. They utilized materials having a cost value of $422,379,638. The principal industries in this class are slaughtering and meat packing; flour milling; butter- and cheese-making; tobacco, cigars and cigarettes; fruit and vegetable preparations; bread and other bakery products, biscuits, confectionery, chocolates, etc.; breweries; woollen clothing; and leather products.

Thus, in addition to providing practically half the domestic market for factory products, agriculture provides considerable raw material to keep factory wheels turning and to provide employment for urban workers.

The *transportation interests* also benefit considerably from the farming industry. Some indication of the importance of farm products to the railways may be gained by consideration of the number of cars of revenue freight loaded on Canadian railways. Deducting the rather large miscellaneous group (which contains much farm produce), fully 20 to 25% of the car loadings of revenue freight is made up of grain and grain products and livestock. Express companies also derive a considerable proportion of their revenue from transport of farm produce. Fresh milk, cream and poultry are commonly shipped by express. In recent years, there has been an increased use of motor trucks for the transport of livestock, fruit and other produce, and this has been a new factor in the creation of employment. The amount of grain transported down the Great Lakes during the season of open navigation is a large figure. The average clearances of grain from the Head of the Lakes during the past five seasons of navigation amount to 160 million bushels. Ocean-going vessels departing from Canadian ports also include in their cargoes a high proportion of Canadian agricultural products. Wheat alone provides an annual export of 242 million bushels on the basis of the past ten years. Wheat flour exports account for an additional 40 million bushels of our wheat.

During the depression years, the contraction in traffic is not nearly as great in farm products as it is in manufactured goods and equipment. Since freight rates suffer only small reductions, it follows that agriculture is an important factor in maintaining rail, lake and ocean-going transportation services during a period of depression. This fact was very evident during 1932.

Using the figures for revenue freight carried by Canadian railroads in 1930 and 1932, the total decrease was from 95,833,228 to 60,468,093 tons, which amounts to 35,365,135 tons or 37%. Agricultural products, however, declined only 762,586 tons (from 19,648,603 to 18,886,017 tons) or 3.9%, while 'animal products' declined 338,268 tons (from 2,513,206 to 2,174,938 tons) or 13.5%. Considering the entire decrease (35,365,135 tons) between the two years, 'agricultural' and 'animal products' accounted for only 3%, while mine products accounted for 46%, forest products 19%, and manufacturing and miscellaneous 32%.

The only increases between the two years were in farm products— wheat, oats, hogs, poultry and other packing house products.

Stated in another way, agriculture provided 23% of the total revenue freight in 1930 and nearly 35% in 1932.

The years 1930 and 1932 are fairly suitable for the comparison since the grain crops of the previous years (1929 and 1931) were similar in size while the crops of 1930 and 1932 were roughly comparable.

Place of Agriculture in External Trade

Canada's export of agricultural products is a large factor in maintaining her position as the seventh largest contributor to world trade. In the calendar year 1932, Canada stood fifth in exports, ninth in imports, and seventh in total trade among the nations of the world. Nearly 32% of Canada's total foreign trade was composed of articles of farm origin in the fiscal year 1932-33. Over 46% of our total export trade in the fiscal year 1932-33 was made up of trade in products of farm origin. This percentage is higher than in the previous year but lower than in some past years because of the greater relative depreciation in agricultural prices and because of the particular impediments to trade in farm products recently instituted by European countries. Practically 15% of Canada's total import trade in 1931-32 was in products of farm origin. Comparing imports with exports, it is readily seen that, since agricultural exports relate to agricultural imports in the ratio of about 3¾ to 1, domestic agriculture has an important place in the balancing of our international indebtedness. This ratio has widened as the depression has become more severe. Our exports of agricultural products have declined in both amount and value as the depression has deepened, and lower proportions of our farm production are going into the export trade, but the decline in exports from other branches of our economic life has been relatively greater. Thus Canadian agriculture has been a decidedly strengthening factor in our foreign trade situation.

The effect of our wheat exports on foreign exchange rates is a well-known fact of which we have had a striking demonstration as recently as the fall months of 1932, when heavy sales to the United Kingdom notably strengthened the Canadian dollar in terms of the pound.

Farm Prices and Income

As previously stated, the prices of farm products fall first and furthest during a depression. Their movement during the past 3 or 4 years has been typical in this respect. The wholesale price index of Canadian farm products has been below the general price level on a 1926 base since June, 1930. Thus the farmer's dollar has been deficient in purchasing power for the past 3½ years. The purchasing power of the farmer's dollar (measured by the relation of wholesale farm prices and the general price level) reached its low point in December, 1932. The rise from this level was fairly slow for four months but became extremely rapid during the early summer. Influenced mainly by rising grain prices, the upward movement reached a peak in July. Then there were steady declines until the October figures were back to the May level, but still 12% above the level of October, 1932. The November index showed a reasonable increase and the December index (53.3) was slightly lower and yet 25% above the level of a year previous.

The relation of wheat prices and the general price level is another interesting consideration. Using 1926 as a base, the index for No. 1 Northern Wheat fell from 87.0 in January, 1930, to 28.3 in December, 1932. It rose to 55.8 in July, 1933, and dropped again to 40.3 in December, where it is 42% above the level of December, 1932. The general index of wholesale prices (1926=100) fell only from 95.3 in January, 1930, to 69.0 in December, 1933. Thus, between the year 1926 and December, 1933, wheat prices fell 59.7 points while the general wholesale index fell 31.0 points. These figures

for the major crop reveal not only a great decline in wheat prices, but a much greater decline in purchasing power.

The agricultural season of 1933 has been featured by reduced crop production and rising prices. Grain production is 32.3% lower than in 1932, while the production of the remaining principal field crops, such as potatoes, sugar beets and forage crops is reduced 9.8%. The rise in prices is considerable but is not yet sufficient to offset the lower production. The decline in total value of the principal Canadian field crops in 1933 as compared with 1932, if present price levels are maintained, will not exceed 6 or 7%.

Turning to livestock, prices received for cattle and calves are about 15% lower than in 1932 while lamb and hog prices are up at least 25%. It seems likely that the income from live stock in 1933 will not be greatly changed from that of 1932.

The dairy farmer is in a slightly worse position than in 1932. Butter production is higher but lower prices have been more than offsetting. Cheese production is down about 15% and prices are about the same as last year. Fluid milk prices are equal to or higher than the prices reigning in 1932 but the demand is slightly reduced.

The poultry producer has not improved his position but the higher prices obtained for eggs and poultry recently have been encouraging.

Despite these encouraging price advances, the gross agricultural revenue of Canada in 1933 will not be over 45% of the 1926 figure, which was $1,717,-477,000. In 1932, our gross agricultural revenue was only $711,898,000, which in itself is a striking example of the severity of the farm depression.

A further comparison of the years 1926 and 1933 reveals that crop production is now lower and that the numbers of livestock on farms are practically the same as in 1926. The number of people on farms has increased slightly and the acreage tilled is about 4 or 5% higher. It seems logical to conclude, then, that the troubles which beset Canadian agriculture are not self-inflicted. They are not indigenous to agriculture, but foreign. With some exceptions, they are not resultant from supplies in excess of ordinary requirements, but from effective demand declining below its usual levels.

Excepting wheat, cattle and some dairy products, the decline in prices is not due to maladjustments in supply. The greater part of the tremendous price declines must be attributed to the demand side of the common equation rather than to an abnormal increase of marketable supplies. All farm prices have suffered drastic declines. It is true that the farmers have missed some opportunities—production of some agricultural commodities has been continued beyond the point where supplies could be profitably cleared. In other cases, new markets for specific Canadian farm products as created by trade treaties have not been sufficiently supplied.

Looking further into the cause of price change through declining effective demand, it is seen that domestic consumption has been well maintained in quantity. It has increased relatively, if not absolutely, as 90% of our farm production is now retained for domestic use compared with only 60% five years ago. This leaves foreign demand as the principal variant. The improved economic conditions of the United Kingdom and Europe during 1933 justify the hope that this situation is being corrected.

Canadian agriculture is essentially made up of farm homes. The common form of tenure is ownership, although this state is decreasing slightly at the expense of tenancy and part tenancy. Still in June, 1931, 586,299 farms or 80.4% of the 728,664 farms in Canada were owned by their operators. Another 67,942 farmers (9.3%) were part owners and part tenants. As a charge on the owned farms in June, 1931, stood mortgages to the amount of $677,564,100. The total farm mortgage debt of Canada at that time is estimated at about $726,000,000. This is not an excessive burden in normal times, but there is evident need for liquidation when farm revenues are so low and when farm products have such a small fraction of their usual purchasing power.

Agriculture in Depression

In summarizing their recently-published volume on *Voluntary Allotment*, the authors, Mead and Ostrolenk give this terse description of the plight of American agriculture:

"Agriculture has continued its downward course until its products, still flooding in undiminished volume into saturated markets, are selling at the lowest prices in recorded history; until bankruptcy is an almost universal phenomenon; until farm wages have fallen to pre-Civil War levels; until the largest of American industries is prostrate."

While the same degree of depression has not been evident in Canadian agriculture, largely because of better conditions prior to 1929, we have the same difficulties attendant upon extremely low prices, grain surpluses, falling land values, and high mortgage debts and other fixed charges.

The deflated position of agriculture cannot be based on prices alone. Production must be considered first. Modification of the crop and livestock enterprises in our production programme has been found necessary throughout the depression and is still continuing as new immediate surpluses appear and new opportunities in other lines present tnemselves. The efficacy of this method of correction, however, can easily be over-estimated. A basic difficulty of agriculture in depression is that the amount of production cannot be controlled. When nature does not interfere, production is maintained at normal levels and prices must suffer drastically. Industry, of course, may roughly adjust its output to demand; both output and working time may be cut, and wage rates and the prices of goods maintained or reduced slowly and in less degree. This, however, is nothing more than the usual explanation of the disparity between farm and retail prices which is engendered as the world goes into depression. Urban wage rates and rents, prices of manufactured commodities, transportation rates, service charges, and middlemen's margins contract reluctantly and slowly.

Secondly, definite reductions in the farmers' out-of-pocket costs of production have been made. Undoubtedly, agricultural costs have been lowered more than industrial costs in the past two decades, and even since the commonly-used base period, 1926. Much of this cost reduction is the product of necessity—simply stated, the farmers had no money for many of the purposes previously regarded as reasonably necessary. Thus when we state that farm prices have fallen much more than retail prices since 1926, we are merely recognizing in part that farm costs have been lowered to a greater extent. Realizing that prices in the long run must be correlated with costs, we admit tacitly that previous ratios between farm and other prices (e.g. 1926 or even

1913) are not presently applicable—that a return to equivalent purchasing power is not indicated by the trend in costs in the interim. In any event, the return to relative parity between farm and retail prices will probably be slow.

It is evident that reductions in overhead costs at a given point of time are of as much benefit to the financial position of the farmer as increases in farm prices. The two vital correctives of the present farm problem are to be found in higher prices and lower overhead costs. Ordinary out-of-pocket costs have already been forced drastically downward. Since the beginning of the present depression, there has been a pronounced trend among farmers to achieve a complete subsistence from the farm. The first step in this programme is diversification of production—a definite plan to produce on the farm the foods necessary for the family, and the feed required by the farm livestock. These economies are extended by reduced expenditures for clothing and other necessities and luxuries. A great economy is made by farmers in the utilization of time. Family labour is used more completely and the farmers themselves have applied themselves more closely to the farm work. Part of this latter phase is a forced economy because there are fewer opportunities for outside employment. This greater utilization of labour has caused a marked decline in the expenditure for hired help.

The question of costs is troublesome because it is difficult to distinguish between reduction in costs and reduction in standards of living. During the decade or more previous to 1930, farmers became accustomed to more farm conveniences, higher education for their children, more "city" distractions. In some cases, such as expenses for automobiles, radios, power plants, etc., it is not possible to draw a hard and fast line between living standards and necessary expenses. Both have been cut severely. In the meantime, it will probably be found most heartening to use the 1913 rather than the higher 1926 base for price indexes. Present farm conditions are much more closely related to those of 1913. Many of the significant features of our agriculture developed during the war and post-war periods of relative prosperity, and have now been abandoned. Tractors and automobiles have given place to horse power; family work has displaced hired labour; many of these features may be regarded as retrograde, but they are logical steps in a forced economy. They all tend to make comparison with 1913 conditions more tenable.

The complete result of this economy, reduction of expenditure and reduction of costs, is that the farm business is placed in a sound position to benefit from improvement of prices. It is clear that since expenses and costs are reduced so drastically, the possibilities and extent of profits are greatly improved. It is this fact which justified hope in the internal farm situation at the depth of the depression.

Our agricultural price structure is largely dependent upon world conditions. Small surpluses exist in the majority of our agricultural commodities; our export trade would be hampered by purely domestic price increases. The four most important grain crops have exportable surpluses and seven of the remaining eleven principal field crops are definitely produced in excess of domestic consumption. Among the important animal products, seven of the nine are produced in surplus quantities. Domestic stocks will increase if our prices are not kept on a competitive basis with other countries. Higher prices as a remedy for the farm situation should come from improvement in foreign demand rather than from domestic initiative. Thus our main hope

in better farm prices lies in better economic conditions in the markets of the world—it has been previously suggested that this hope is not forlorn.

A third consideration in the farm problem is that of taxes. The tax load on Canadian farm property is not nearly as burdensome as in the United States where government and county services are much more highly developed, with proportionately higher expenses. The local unit, whether the county or the municipality, still depends on the property tax for its revenue. This tax, of course, being inelastic, is particularly burdensome in times of reduced farm revenue. Arrears are inevitable and have been mounting in many districts. Tax rates per acre of farm land did not decline until 1932, and the adjustment is not nearly commensurate with the reduction in farm revenue.

Fourthly, the relation of mortgage debts to land values is a pressing problem and constitutes a great worry to the farmers themselves. The total value of Canadian farm lands has fallen approximately 40% since 1929. As farm income falls and taxes remain stationary or else increase, land values decline. The market for farm land becomes greatly restricted and, in some cases, buyers are not available at any price. The farm mortgage debt, being either stationary or increasing, forms a higher proportion of the falling land values. The farmer sees his equity, established by years of effort, decline and perhaps disappear. The resultant discouragement and despair are reasonable reactions. These, in addition, affect the farmer's estimate of prospective income, and have a further influence in reducing land values. Farm debts are the greatest problem at the root of the agricultural situation, and the purchasing power of the Canadian farm population must be restrained as long as a farmer's debts exceed the sale price of his land.

These reflections emphasize the serious position of the Canadian farm industry. They demonstrate the difficulty—the practical impossibility—of meeting debts contracted before deflation began in 1929 from an income reduced in the drastic manner shown. They stress the point that reduction of ordinary costs of production and expenses of living constitute the first method of meeting the farm depression, but that this is inadequate and must later be assisted by liquidation of debts and appreciation of prices. Restrictions on foreclosure are a valuable accompaniment to these forces. They prevent despair, eviction, and wholesale abandonment of farm lands.

It is possible, however, to over-emphasize the dangers in the present situation. The position of the farmer is subject to sudden and rapid change. Farm prices usually are the first to react upward from the depression. The various factors bringing deflation of income and values furnish their own antidotes and correctives. The very severity of the necessary downward adjustment in expenses measures the degree of saving and forecasts the benefit to arise when prices begin their inevitable increase. The rapidity of emergence from the depression depends on the reduction of costs, since rising prices will then become profitable sooner. Thus, it may be argued that the depression has brought about some beneficial changes in our economic system. The emergence from the present agricultural depression will not be as pronounced as in 1924. The expectations aroused in the first half of 1933 have been partly shattered; speculation on the prospects of inflation was mistaken for the long-awaited basic recovery. But a part of the price advance has been retained. The upward movement may be erratic but there is real evidence that it has begun.

THE LIFE HISTORY AND PARASITISM OF *TAPHRINA DEFORMANS*

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INTRODUCTION

Although *Taphrina deformans* (Fcl.) Tul. has long been recognized as the causal agent of peach leaf curl, and adequate descriptions of its perfect stage, together with the pathological histology of the host tissues involved, have appeared, little is known of the activities of the fungus after the attacked leaves have fallen from the trees or of the time and manner of infection. The investigations which are reported upon herein were undertaken with the hope of elucidating these obscure points in the biology of the fungus. Three main lines of attack were adopted: the relations of weather conditions in the spring to the occurrence of the disease, the biological potentialities of the spores of *Taphrina deformans*, and the progress of infection as indicated by a microscopic examination of material chosen in the light of information obtained from the other two lines of attack.

THE TIME OF INFECTION AND THE RELATION OF WEATHER CONDITIONS TO THE OCCURRENCE OF LEAF CURL IN THE NIAGARA FRUIT BELT

Peach leaf curl can usually be adequately controlled by a single application of fungicide to the dormant trees. In the Niagara fruit belt where the occurrence of the disease makes spraying essential, a lime sulphur spray is applied in March or April depending upon seasonal conditions. While the general success of this spray is beyond question, nevertheless there are seasons in which local epiphytotics of leaf curl occur. Usually these outbreaks are attributed to faulty spraying and in many instances this is doubtless the explanation, but in certain years the disease is altogether too prevalent for its presence to be explained entirely on this basis. For example, in the year 1929 leaf curl was so severe that a number of orchards were almost completely defoliated and, although in some of these the trees had not been sprayed until after the buds were open, there were others in which the spray had been applied before the buds showed any signs of activity. Moreover no correlation could be found between the dates of spray application and the degree of control obtained. Faulty spraying obviously cannot account entirely for such discrepancies and their complete explanation demands a knowledge of time and manner of infection.

Now if a series of sprays were applied to separate trees or branches throughout the early spring, the date on which the spray ceased to be effective would determine the approximate time at which infection had occurred. This information could then be correlated with the weather conditions which obtained at that time and some general conclusions with regard to the epidemiology of the disease arrived at. Moreover, such experiments should indicate whether or not the failure to control the disease in certain years is due entirely to faulty spraying. Experiments of this nature were begun in

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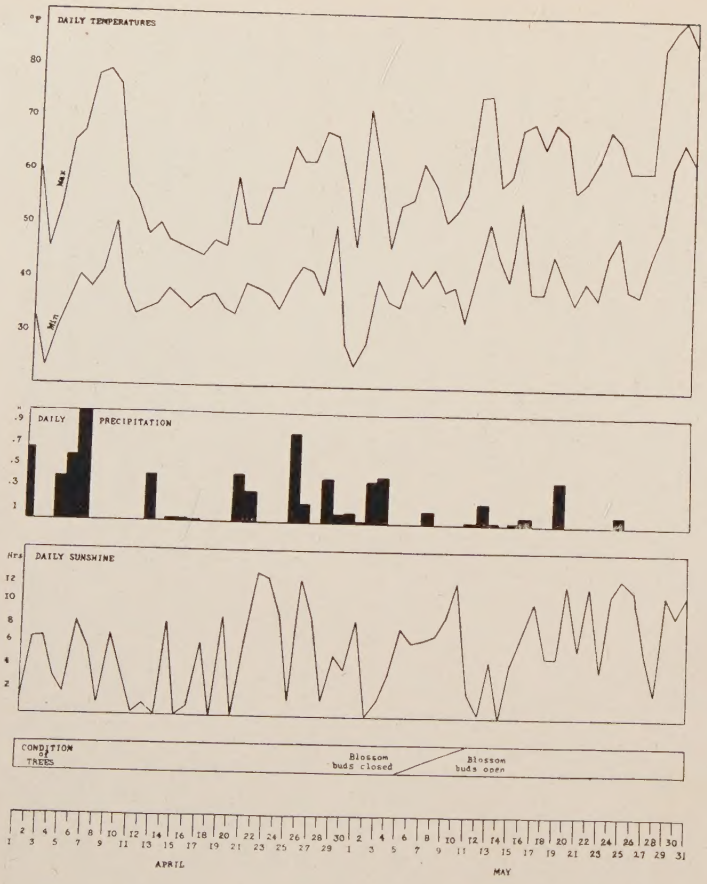

FIGURE 1. Summary of temperature, precipitation, sunshine, and condition of trees in the spring of 1929.

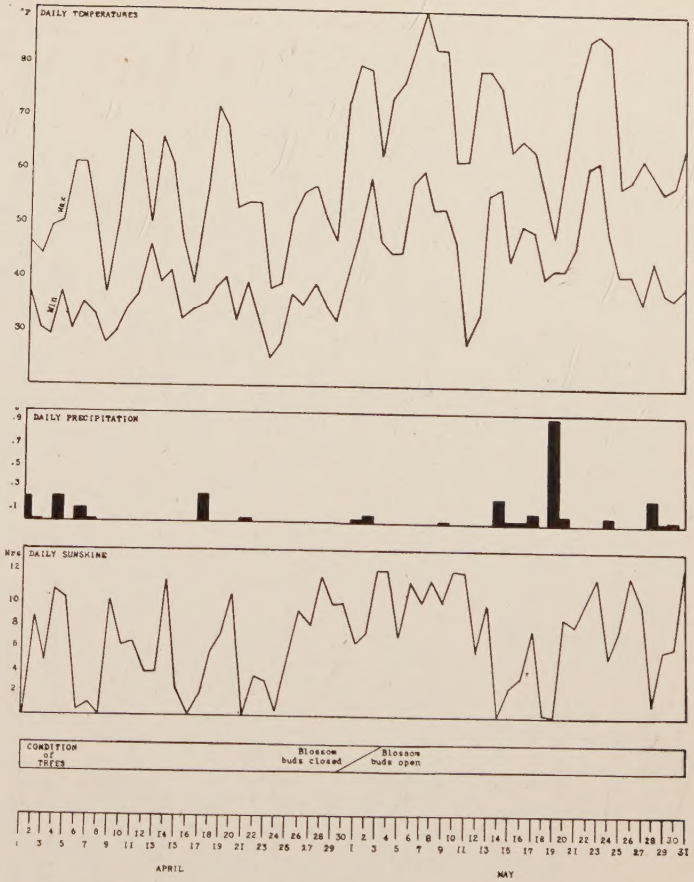

FIGURE 2. Summary of temperature, precipitation, sunshine, and condition of trees in the spring of 1930.

1930. Unfortunately, in contrast to 1929, the spring of which had been cold and rainy and particularly favourable to leaf curl (Figure 1), the spring of 1930 was an exceptionally dry one (Figure 2) and it was difficult to find curled leaves even in unsprayed orchards, so that no significant data were obtained from the spraying experiments of that year. The experiments made in 1931 and 1932 were more successful and these will now be described in some detail.

Spraying Experiments in 1931

In this year a deserted orchard about two miles east of the Vineland Horticultural Experiment Station was selected. This orchard had not been sprayed in 1930 and some leaf curl had developed in it even in that unfavourable year. Selected limbs of different trees were sprayed at intervals throughout the middle and latter part of April. Four limbs were sprayed on each date so that a satisfactory distribution of the experimental material might be obtained. It was found that a little hydrated lime added to the spray mixture served to indicate how well the spray was covering. On some days high winds made it necessary to allow one application of spray to dry and then to apply a second one to ensure that every bud had been wetted.

The spring of 1931 proved a more favourable one for leaf curl than was the spring of 1930. The first signs of the disease could be readily recognized by May 18, and by June 1 ascospore discharge had commenced. Since the diseased leaves fall soon after the fungus discharges its spores, the results of the experiment were taken on June 3. These results are presented in Table 1.

Figure 3. The stage of development on April 24, 1931 –the last date on which spraying gave perfect control—of the buds in the orchard where the 1931 spraying experiments were conducted.

TABLE 1.—THE RESULTS OBTAINED FROM SPRAYING PEACH BRANCHES AT DIFFERENT DATES DURING THE SPRING OF 1931

Date of spray application	Number of branches sprayed	Percentage of leaves curled	Percentage control
April 15	4	0	100
" 16	4	0	100
" 17	4	0	100
" 18	4	0	100
" 20	4	0	100
" 24	4	0	100
" 29	4	27	55
Unsprayed checks	–	60	–

From these results it is clear that no infection had occurred up to April 24. The buds at that time were well advanced and the young leaves were about half an inch long (Figure 3). Between April 24 and April 29 consider-

able infection must have occurred, because the spray applied on the 29th did not completely control the disease, although it markedly reduced the percentage of leaves which became infected as compared with unsprayed checks. The leaves from representative branches were removed and graded on the following basis: *healthy*—showing no curl whatever; *slightly curled*—less than one quarter of the leaf surface diseased; *moderately curled*—one quarter to three quarters of the leaf surface diseased; *completely curled*—three quarters or more of the leaf surface diseased. The results obtained from such a count of the leaves from two of the limbs sprayed on the 29th and from two unsprayed limbs are given in Table 2.

TABLE 2.—A COMPARISON OF THE LEAVES FROM TWO BRANCHES SPRAYED ON APRIL 29, 1931, AND FROM TWO UNSPRAYED BRANCHES

Date of spray application	Total number of leaves counted	Percentage of leaves curled			Total percentage curled
		Slightly	Moderately	Completely	
April 29, 1931	2331	8	7	12	27
Unsprayed checks	1526	14	14	32	60

The chart in Figure 4 shows the relation of these results to the conditions prevailing at the time the spray applications were made. The leaf buds in the peach orchard where the experiment was conducted began to swell about April 13 and by the 15th most of the terminal buds showed two or three millimetres of green tip. From April 10 to April 22 the days were clear with rising temperatures. On the night of April 22 the sky became cloudy and a period of cold damp weather set in. On April 29 the sky cleared but the temperature did not rise appreciably until May 2. From May 2 to May 6 the weather was fair and warm. On the night of May 6 a second period of damp cloudy weather set in. This lasted more or less intermittently until May 14 when the sky cleared and the temperature began to rise. May 15 was warm but somewhat cloudy; rain followed the next day and the temperature dropped after the rain ceased. May 17 was cool but clear. By this time the trees were well advanced and in full blossom. Leaf curl could be readily recognized on the unsprayed trees and on those limbs which were sprayed on April 29. The weather then remained fair and became warmer until May 23 when the fourth period of rain began. This lasted until the 26th, after which the sky cleared and the temperature rose to summer levels.

These experiments show that approximately half of the infection had occurred by April 29, which marks the end of the first period of wet weather. The fact that the branches which were sprayed on April 24 remained free of curl, narrows the time during which this fraction of the disease became established beyond the reach of the fungicide to four days. It is unfortunate that no branches were sprayed after April 29 so that the remainder of the infection might have been accounted for, but the buds were so far advanced by this date that further spraying would have been dangerous to the fruit and foliage.

The general experience of the peach growers in 1931 further substantiated the results of this experiment. Those who had sprayed in the early spring obtained a complete control of leaf curl and no discrepancies such as had occurred in 1929 were reported.

Spraying Experiments in 1932

The experimental material for 1932 was limited to two trees of a group of three on the Horticultural Experiment Station at Vineland. These trees stood together on fallow land and were well isolated from other peach trees. They had been so severely attacked by leaf curl in 1931 that they were almost completely defoliated at that time. Branches of these trees were sprayed at different dates throughout the fall of 1931 and the spring of 1932. Unfortunately, owing to the limited amount of experimental material available, only one or at the most two branches could be sprayed on each date. The results obtained are presented in Table 3.

TABLE 3.—THE RESULTS OF THE SPRAYING EXPERIMENTS OF 1932

Date of spray application	Number of leaves counted	Percentage of leaves curled			Total percentage curled	Percentage control
		Completely	Moderately	Slightly		
Sept. 17, 1931	1989	18	19	24	61	36
Nov. 1, 1931	1493	5	9	17	31	67
Mar. 20, 1932	4406	4	3	6	13	86
Apr. 7, 1932	4534	2	3	5	10	89
Apr. 8, 1932 (a)	3527	9	10	13	32	63
Apr. 8, 1932 (b)	2191	10	10	16	36	
Apr. 11, 1932	2668	3	4	5	12	87
Apr. 14, 1932	2212	2	1	3	6	94
Apr. 27, 1932	3140	3	2	2	7	93
May 1, 1932	1721	12	6	4	22	77
May 12, 1932 (a)	2593	27	14	12	53	46
May 12, 1932 (b)	2866	22	14	14	50	
Check	800	80	9	6	95	—

In contrast to 1931 the occurrence of leaf curl in 1932 was quite general throughout the Niagara fruit belt and many orchards which had been sprayed before the leaf buds began to open exhibited a surprisingly high incidence of the disease. Moreover, as in 1929, there seemed to be no correlation between the dates of spray application and the degree of control obtained. In the light of these general observations the results obtained from the spraying experiments prove particularly significant, for somewhat the same discrepancies are reflected in them. The unsprayed limbs which acted as checks were uniformly and severely diseased and all of the sprayed branches exhibited more or less curled leaves. Although the experimental material was decidedly limited and the size and position of the individual branches undoubtedly influenced the results obtained, yet, as can be seen from Table 3, there was a general tendency for the efficiency of the sprays to increase from September 1931 to April 1932 and then to decrease rapidly as the spring advanced. The extraordinarily heavy development of curl on the two branches sprayed on April 8 is probably due to the fact that the trees were wet with rain when

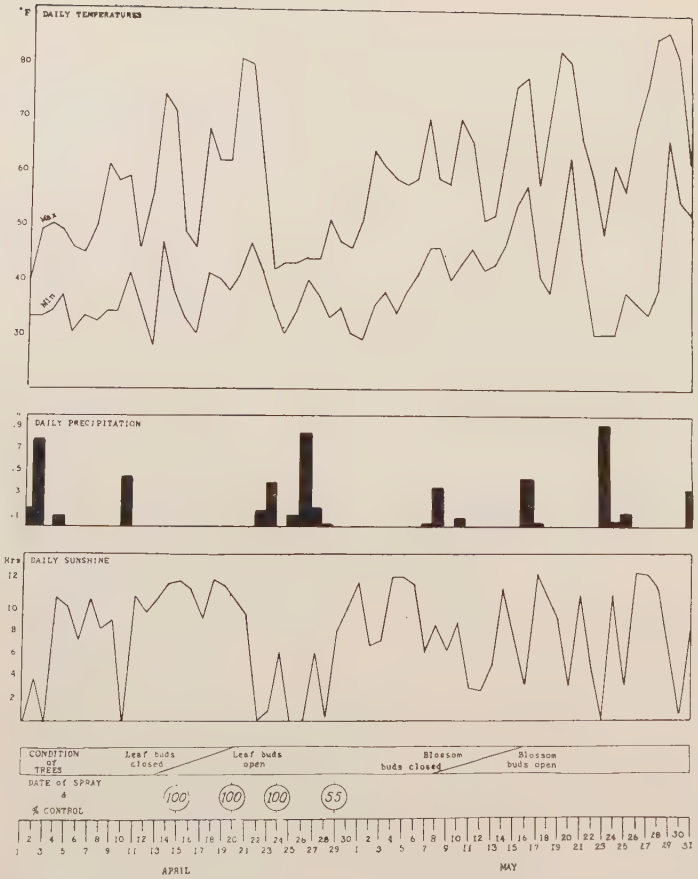

FIGURE 4. Summary of temperature, precipitation, sunshine, condition of trees, and the dates and results of the spraying experiments in 1931.

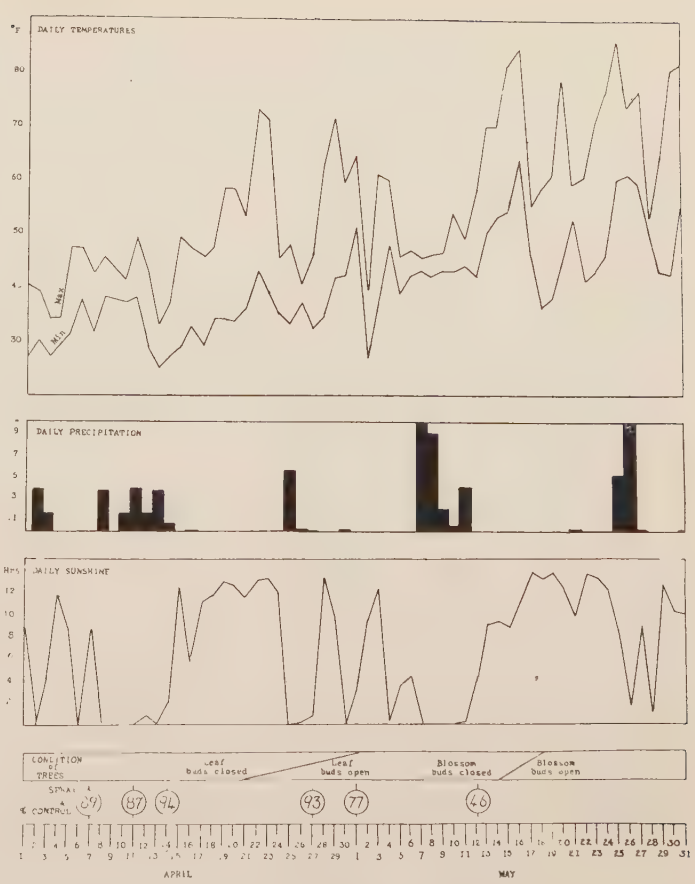

FIGURE 5. Summary of temperature, precipitation, sunshine, condition of trees, and the dates and results of spraying experiments in 1392.

the spray was applied and that it rained again soon after the application was made and before the spray had had time to dry. The results obtained from these branches are therefore not comparable with the rest of the experimental data. They are included because they show the uniformity with which the trees reacted to the sprays under a given set of conditions. This uniformity can also be seen in the results from the two sprays applied on May 12. In both cases the limbs in question were on different trees.

The chart in Figure 5 shows the relation of the results obtained from the branches which had been sprayed in April and May 1932 to the conditions prevailing that spring.

The first two weeks of April were cold and rainy but on April 15 the weather cleared and from the 17th to 23rd the days were sunny and the temperatures rising. On April 23 the temperature dropped and a period of cold damp weather set in. This lasted until April 28 and was followed by a comparatively clear warm period. On May 6 a second period of cold wet weather began. This extended until May 12 after which the sky cleared and the temperature rose.

The leaf buds began to loosen during the first period of warm weather and by April 21 the most of the terminal buds were showing green at their tips. The cool weather from April 23 to April 28 checked any further development but during the second period of warm weather from April 28 to May 6 development was rapid. The blossoms began to open about May 14 and the leaves unfolded soon after. Leaf curl could be definitely recognized on all the branches by May 16.

Although the sprays which were applied in March and April did not entirely control the disease, they reduced the percentage of curled leaves far more than did the sprays applied the previous fall. This would seem to indicate that the fungus was able to spread to the fall-sprayed branches during the winter and early spring although infection did not occur until after the buds had opened and green tissue was exposed. With the exception of the spray applied on April 8, the early spring applications were relatively efficient and controlled approximately 90% of the disease. The decrease in control on May 1 to 77% is significant and indicates that some infection had occurred during the latter part of the rainy period which extended more or less constantly from April 23 to April 28. By May 12 the efficiency of the spray had fallen to 46%, showing that by this time more than half of the infection had been successfully established and was beyond the reach of the fungicide.

It should be noted that in both 1931 and 1932 a large percentage of the disease can be accounted for only by assuming that sprays applied immediately after periods of rains can inhibit the development of the fungus in the early stages of the infection process.

The Biological Potentialities of the Spores of *Taphrina deformans*

Although in the Vineland district the ascospores of this fungus are discharged in the early summer, summer infection very rarely occurs and all evidence of the disease disappears with the dropping of the attacked leaves in June and July. Although it is an obligate parasite and cannot complete its life cycle saprophytically, the ascospores possess the potentiality of

budding after the manner of the common yeasts, and cultures of these budding spores can be propagated indefinitely on artificial media. The fate of the fungus from the time the ascospores are discharged until the reappearance of the disease in the following year has never been actually determined, but all of the evidence obtained from spraying experiments indicates that perennial mycelium does not occur and that either the ascospores or their progeny are responsible for the recurrence each year of the disease. A study of the biological potentialities of these spores should throw some light on this question.

Isolation and Culture of the Spores

The ascospores may be discharged forcibly or they may remain in the ascus and bud *in situ*. The factors which determine the mode of behaviour were not studied, but no difficulty was encountered in obtaining discharge from diseased leaf tissue with mature asci. The spores as they are discharged from the ascus cling together in a little ball and the tiny spore balls may be blown some distance without breaking up. Thus when curled leaves were fastened to the guard of an electric fan, the little packets of spores could be caught on slides some six feet away. However, these spore packets disintegrate immediately when brought into contact with a drop of water and the eight ascospores float apart from one another.

Monospore cultures were obtained in the following manner. Small pieces of curled leaves from which the asci were actively shooting their spores were attached to glass slides by vaseline. These slides were supported above sterile slides on which were placed drops of sterile water. After a number of spores had collected in each drop, the spore suspension thus obtained was streaked on the surface of plates of clear potato dextrose agar by means of a sterile loop. The plates were inverted and examined under the microscope. Single spores well separated from their neighbours were looked for and marked. When the colonies produced by the budding of these spores had attained a diameter of about half a millimetre they were picked off with a sterile platinum needle and transferred to slants of potato dextrose agar in culture tubes. In this way thirty monospore strains were obtained, each being the progeny of a single ascospore. These strains were cultured separately and they, together with a culture made by mixing the progeny of a large number of ascospores, were used in the cultural and infection experiments.

The cultural characteristics of *Taphrina deformans* growing on artificial media have been described by a number of authors (*2*, *7*, *8*). Growth is slow and appears to be favoured by the use of a soft agar medium. The colonies resemble those of a yeast. They are convex, shiny, butyrous and white in colour when young, becoming slightly pink with age. In broth culture growth is entirely sedimentary and the liquid remains clear.

The spores will bud readily in broth media of various sorts, but the heaviest growth is obtained in those media which contain some vegetable extract, such as potato extract, as a base. The function of the potato extract appears to be entirely a nutritive one for it was found that the ultimate growth as estimated by the degree of turbidity of the broth varied in direct proportion to the concentration of potato extract used. It is interesting to note that growth sufficient to produce a slight turbidity occurred even in a solution containing as low a concentration of potato extract as .008% in distilled water.

The temperature relations of *Taphrina deformans* in culture have been investigated by Mix (*8*) who found that the optimum temperature for growth on potato dextrose agar was just below 20° C., the minimum below 10° C., and the maximum somewhere between 26° and 30° C. While Mix's work was not checked in detail, his findings were in every respect substantiated during the routine of culturing the organism.

In actively growing cultures the conidia are slightly oval in shape and vary from 2.5-6μ x 4-8μ in size. Budding occurs as in yeast cells by the outgrowth of a daughter cell from one end of the parent cell. Often a second daughter cell begins to form before the first one is set free (Figure 6). In old cultures where budding is less frequent, the cells are more varied in appearance and atypical forms frequently occur. Of these atypical cells the most striking are those which possess thick walls (Figure 6, 6-11) and it has been suggested that these are resting cells which play the important rôle of tiding the fungus over unfavourable periods. Mix (*9*) believes these so-called resting cells are ascogenous cells and that the diploid stage can occur saprophytically.

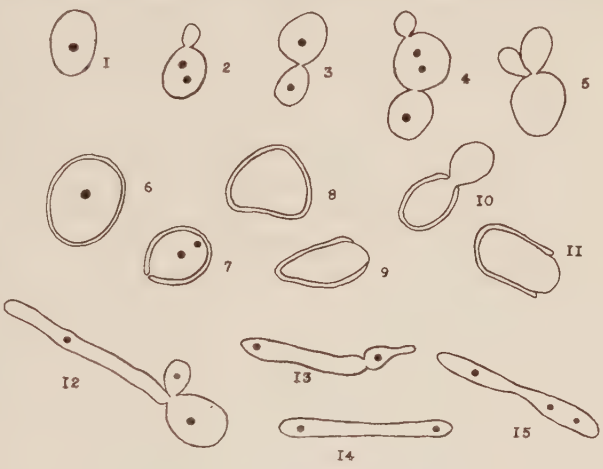

FIGURE 6. Sprout conidia of *Taphrina deformans* from monospore cultures. 1-5 Typical cells from an actively growing culture. 6-11 Atypical cells of the thick walled type from an old culture. 12-15 Atypical cells producing various forms of hypha-like outgrowths x 1400.

A true mycelium is never formed in culture but occasionally cells are found which, instead of producing typical sprout conidia, have given rise to very elongated outgrowths resembling germ tubes (Figure 6, 12-15). Wieben (*10*) and Mix (*9*) have both claimed that these germ tubes are initiated as a result of the copulation of sprout conidia in a manner comparable to that occurring in a number of smut fungi. Wieben has studied the copulation process in *Taphrina epiphylla* Sadeb. and T. *Klebahni* Wieben where she finds that two sprout conidia of opposite potentiality come to lie close together and on the side of one cell a fine papilla-like outgrowth is formed which fuses to the side of the other cell. The contents of the first cell pass through this connecting bridge and enter the other cell which immediately germinates to produce the so-called germ tube. In *T. epiphylla* and *T. Klebahni* these germ tubes are very long and are septate, whereas the atypical elongated cells found in cultures of *T. deformans* seldom exceed three to four diameters of the parent cell in length and are never septate (Figure 6, 12-15). Furthermore they were found quite as frequently in the single ascospore cultures as they were in mixed cultures, a fact which at once precludes a copulation of genetically different spores being responsible for their origin.

The Longevity of the Sprout Conidia

It is quite evident that if the spores are responsible for the reappearance of the disease each spring they must be able to withstand desiccation and remain viable throughout the temperature extremes of summer and winter. Viability tests made by Mix (*8*) have shown that the sprout conidia when dried upon glass cover slips are capable of remaining alive for 140 days at 30° C. and 315 days at lower temperatures. In order to test the viability of the sprout conidia still further a somewhat different procedure was adopted. This consisted essentially of inoculating sterilized soil with a suspension of sprout conidia and re-isolating the organism as required. Small flasks were used for the soil and re-isolations made by transferring samples to potato dextrose broth with a sterilized loop. All results were checked by microscopic examination.

In order to determine whether or not the viability of the thick-walled atypical cells was greater than that of the actively budding conidia, suspensions from both young and old cultures were used. The young cultures were obtained by repeated transfer to soft potato dextrose agar set in a thick layer on the bottom of a 250 cc. flask. The transfers were made by washing the spores with sterile water and using a few drops of the suspension so obtained as inoculum for other similar flasks. In this way very uniform cultures which showed no atypical cells could be maintained. Old cultures displaying a large percentage of atypical cells were easily obtained in a few weeks by placing the flask cultures in a warm room. It may be noted here that cultures kept in the refrigerator formed atypical cells much more slowly than did cultures kept at room temperature, whereas those placed in the incubator at 28° C. produced a variety of involution forms in a short time. The cultures kept in the refrigerator remained viable for months, those at room temperature tended to die out after about six weeks, while those in the incubator were dead at the end of two weeks. For this reason, in all experiments involving the use of old cultures, the viability of the culture used was tested by transfer to an agar slant at the time the experiment was set up.

On December 14, 1930, a series of flasks, each containing 50 grams of sterilized soil was inoculated with a spore suspension from an old culture. Some of the flasks were placed out-of-doors and the remainder kept at room temperature. On January 25, 1931, a similar series was inoculated with a young culture. Transfers made to potato dextrose broth throughout the winter and summer of 1931 produced growth in all cases. Since the soil in the flasks became quite dry and powdery in a few weeks the sprout conidia must have been quite inactive throughout the greater part of the experiment. The experiment was continued until July 3, 1932, by which date the number of successful transfers was beginning to fall off, indicating that most of the sprout conidia were dead. However, even at this date some of the cells were still alive, for seventeen out of thirty transfers were successful. In the case of the old cultures this was a survival of one year six and one-half months, and in that of the young culture a survival of one year five and one-half months. Thus there was virtually no difference between the longevity of the atypical cells and that of the thin-walled conidia, and under natural conditions either type of cell could be responsible for carrying the fungus through the unfavourable periods of the year.

Isolation of *Taphrina deformans* from Dormant Peach Buds

If the recurrence of leaf curl every spring is to be attributed to spores lodged on the surface of the peach buds, it should be possible to isolate the organism from these during the winter months. To determine whether such isolations were possible, preliminary experiments were made using artificially inoculated material. A dormant peach seedling was inoculated by painting on the buds a water suspension of a young culture. The inoculation was made in January 1932 and the tree was left out-of-doors throughout the experiment. A week later one of the inoculated buds was removed and crushed in sterile water, loopfuls of which were streaked on plates of potato dextrose agar. In twenty-four hours colonies of *Dematium pullulans*, a fungus commonly associated with the bud scales of the peach, made their appearance. Young colonies of this organism are deceptively like those of *T. deformans* but this similarity quickly disappears as the colonies grow older. Two days later colonies of *T. deformans* could be recognized under the microscope and no difficulty was experienced in making transfers of these to potato dextrose slants. In February, March and April similar isolations were made from this tree and this is further evidence that the sprout conidia can withstand the rigors of winter while lodged on the surface of the peach buds.

Encouraged by the results of this experiment isolations were attempted from trees which were known to have been heavily attacked by leaf curl in the spring of 1931 and which had not been sprayed subsequently. Twenty plates of potato dextrose agar were streaked with the washings from buds of these trees and parallel plates were streaked from those of artificially inoculated ones. *T. deformans* was isolated from three of the plates streaked from the uninoculated material and from all of the plates streaked from the inoculated. This is strong evidence that spores lodged on the surface of the trees are responsible for the persistence of leaf curl from season to season.

Infection Capabilities of the Sprout Conidia

Successful inoculation of peach buds with cultures of *Taphrina deformans* has been reported by both Mix (*8*) and Wieben (*10*). Mix made his inoculations in the spring before the leaf buds had opened while Wieben made hers in the summer previous to that in which the disease appeared. Although Wieben has made the suggestion that a copulation between spores of opposite potentiality takes place before infection occurs, she offers no evidence in support of this in the description of her inoculation experiments. Nor do Mix's experiments afford any evidence of the correctness of such a hypothesis since his inoculations were made with a culture derived from the eight spores of a single ascus and not from a single ascospore culture. It seemed highly desirable to determine whether such a copulation is necessary before infection can occur not only because of its fundamental significance but also because if it really were essential this might readily account in part for the marked differences in the seasonal development of the disease.

Obviously if such a copulation is a prerequisite to infection monospore cultures cannot produce the disease. In order to test the validity of such assumptions inoculation experiments were made using monospore cultures as contrasted with mixed cultures. In the fall of 1930 two well isolated peach trees which had been free of curl that summer were selected. On one tree the buds of certain branches were inoculated with a water suspension of sprout

conidia from a culture made from a mixture of ascospores; on the other tree similar inoculations were made using monospore cultures on the individual branches. Check branches were left uninoculated in each case. In the spring of 1931 the inoculated branches on both trees became heavily infected with leaf curl but unfortunately the check branches also showed some diseased leaves. A similar experiment was again attempted in 1932. In this experiment a row of some thirty small trees was used. In September alternate trees on one half of the row were inoculated with a mixed culture and alternate trees on the other half inoculated individually with monospore cultures. The trees between the inoculated ones were left as checks. When leaf curl appeared in the spring of 1932, the entire row of trees was so heavily diseased that it was impossible to draw any conclusion from the experiment.

Since attempts to obtain satisfactory results from trees allowed to remain under natural conditions always seemed to be frustrated by the spread of the spores from the inoculated material to the uninoculated checks, it was evident that little progress would be made until some satisfactory method of obtaining infection under controlled conditions was devised. Accordingly a moist chamber large enough to accommodate potted peach trees was built. This chamber consisted of a rectangular framework of iron piping, the sides of which were covered with canvas and the top roofed with glass. Holes were bored at intervals in the upper part of the frame so that, by connecting this to the water supply, the canvas sides could be kept constantly wetted. In the centre of the roof a ventilator made of six-inch stove pipe was inserted and, in order to maintain the humidity of the chamber at saturation, a fine spray of water was directed into this opening. The nozzle used for obtaining this spray was one originally designed to vaporize oil for a small house-heating unit. This nozzle proved quite satisfactory and gave no trouble throughout the three months during which the moist chamber was being used.

On March 23, 1933, a number of small trees which had been potted in eight-inch pots were brought indoors and placed in a cool greenhouse. Some of the trees were inoculated immediately with a monoascospore culture and others were left uninoculated to act as checks. On April 9, by which time the leaf buds were at approximately the same stage of development as had been those of the trees used for the spraying experiments on May 1, 1932, six inocu'ated and two uninoculated trees were placed in the moist chamber where they remained until April 13. The temperature in the moist chamber during the four days elapsing between April 9 and April 13 was between 40 and 50° F. with a mean of 44° F.; the humidity remained at saturation throughout. On April 28, two weeks after the trees had been removed from the moist chamber, leaf curl was definitely recognizable on the inoculated plants and later the asci formed and ascospore discharge occurred in the normal manner. The uninoculated trees remained healthy.

This experiment proves beyond doubt that single ascospore cultures are capable of producing leaf curl, a fact which at once eliminates copulation of spores of opposite potentiality from being a prerequisite to infection.

The Progress of Infection in *Taphrina deformans*

Materials and Methods

Naturally infected host material of the Elberta variety was used throughout this phase of the work. That intended to illustrate the phases of penetration and the earlier stages of infection had to be chosen especially carefully

because when the leaves can first be recognized as diseased the fungus has already developed considerable mycelium within them and is beginning to bring about the characteristic hypertrophy of the cells. It is impossible to trace infection to its source in such material or to find infection hyphae with spores still attached to them. It was necessary therefore to collect material before any signs of the disease had appeared.

At short intervals throughout the spring of 1932 young leaves from the unsprayed limbs of the trees which were being used for the spray experiments were cut off and fixed in formalin-acetic-alcohol. The branches from which these leaves were taken became heavily infected and the spraying experiments showed that a large part of this infection occurred sometime about May 12. Accordingly the material which was collected on that date was examined. The leaves in this sample were from one to two centimetres in length and the blade was still folded at the midrib. Two methods of examination were employed. The first consisted in clearing the leaf so that the extent of mycelial growth could be seen in its entirety. This was done by first cutting away the midrib and separating the halves of the blade, then boiling these in lacto-phenol with either cotton blue or acid fuchsin until the leaves were cleared and the fungus was well differentiated.

The second method was to examine serial sections of young leaves. The leaves were dehydrated by the ethyl butyl alcohol method of Zirkle (*11*) and embedded in paraffin. The sections were cut at 3-5μ and were stained with iron alum haematoxylin or Flemming's triple stain.

PENETRATION AND SUBSEQUENT DEVELOPMENT OF THE FUNGUS

At the time infection is occurring the host tissue is still meristematic. The palisade layer has not been differentiated and the leaf parenchyma cells are closely compacted together with little or no intercellular spaces between them; some are still dividing. Stomata in all stages of development can be observed on the lower epidermis, the cells of which are elongated vertically and rich in cytoplasm. A few long unicellular hairs occur as out-growths from these cells. The upper epidermal cells are much larger and more vacuolate than are either the leaf parenchyma or the lower epidermal cells. No stomata occur on the upper surface of the leaf.

A number of spores of various kinds lodge on the outer surface of the closed leaf and in the grooves between the halves of the leaf blade. Many of these spores are sprout conidia of *T. deformans* which have not begun to infect, but are still budding upon the leaf surface. They vary somewhat in size but average 3-5μ at their greatest diameter. No large thick-walled spores such as occur in old cultures were observed.

No copulation between spores such as Wieben has described for *T. epiphylla* and *T. Klebahni* occurs prior to infection. When penetration is about to take place, the spores fasten themselves to the leaf surface by means of a short infection thread (Plate I, Figures 1 and 2) which grows out from the end of the spore at the position usually occupied by the daughter bud. As this infection thread presses against the thin cuticle of the leaf a thickening of the cuticle at the point of contact takes place. The contents of the spore pass into the thickened cuticle and the spore collapses. The fungus makes a limited amount of growth within the cuticle (Figure 7 and Plate I, Figures 3, 4 and 5). Penetration may occur on either surface of the leaf.

Figure 1 of Plate II is a photograph of the surface of an infected leaf at this stage. The leaf was cleared in lactophenol to which a few crystals of acid fuchsin had been added. A number of separate infections may be seen. The host cells and the fungus mycelia have not stained but the cuticle in which the fungus is growing has retained the stain to some extent thereby causing the individual infections to stand out in clear relief.

The intracuticular growth is very limited and the fungus soon begins to penetrate into the leaf tissue. This it does by sending down a slender hypha which forces its way between the epidermal cells until it reaches the less compacted parenchymatous tissue beneath the epidermis. Here the hypha branches out and ramifies in all directions, filling what intercellular space there is between the parenchyma cells until these appear to be enclosed in a veritable network of mycelium. Figure 2 of Plate II shows the fungus spreading through the leaf tissue from several points of infection. It will be noted that the direction of spread bears no relation to the leaf veins and that the mycelium passes over these quite readily. At this stage the mycelium is extremely fine and no septa have been formed (Plate II, Figure 3).

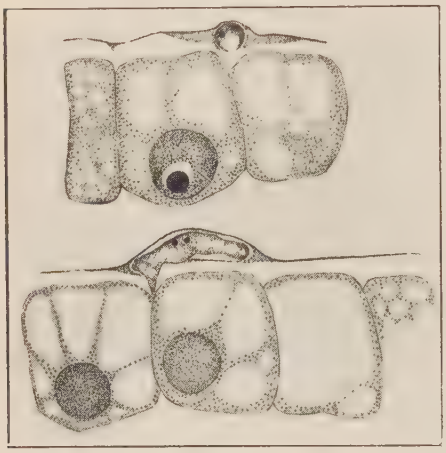

FIGURE 7. The intracuticular development of *T. deformans*.

This picture of the initial stages of the infection process in *T. deformans* which has been obtained from naturally infected material is an entirely different one from that presented by Martin (7) who claims to have found stomatal penetration both with *T. deformans* and *T. coerulescens* on artificially inoculated leaves of the Elberta peach and the bur oak respectively. Martin describes the infecting hyphae as branching dichotomously and having clear septa between the cells. In no instance has stomatal penetration been found in any of the material collected at Vineland, nor have the young hyphae shown any signs of septation during the early stages of mycelial development within the leaf.

In the early stages of infection the fungus does not appear to have any effect upon the host cells but, as soon as the mycelium has penetrated from the cuticle into the parenchyma and established itself there, the cells around the point of infection begin to increase in size. As the host cells enlarge the cuticle above the area of infection is stretched and the intracuticular mycelium collapses and dies leaving only a dark-staining area to indicate its position.

Meanwhile the leaf is maturing rapidly and there comes a stage at which the fungus no longer encroaches upon healthy tissue but remains strictly localized in the already invaded regions. Here the host cells increase in size, lose their chlorophyll, and often accumulate a red pigment in their enlarged vacuoles. Only those cells which are in actual contact with the mycelium appear to be affected and this causes the diseased tissue to appear sharply delimited from the healthy.

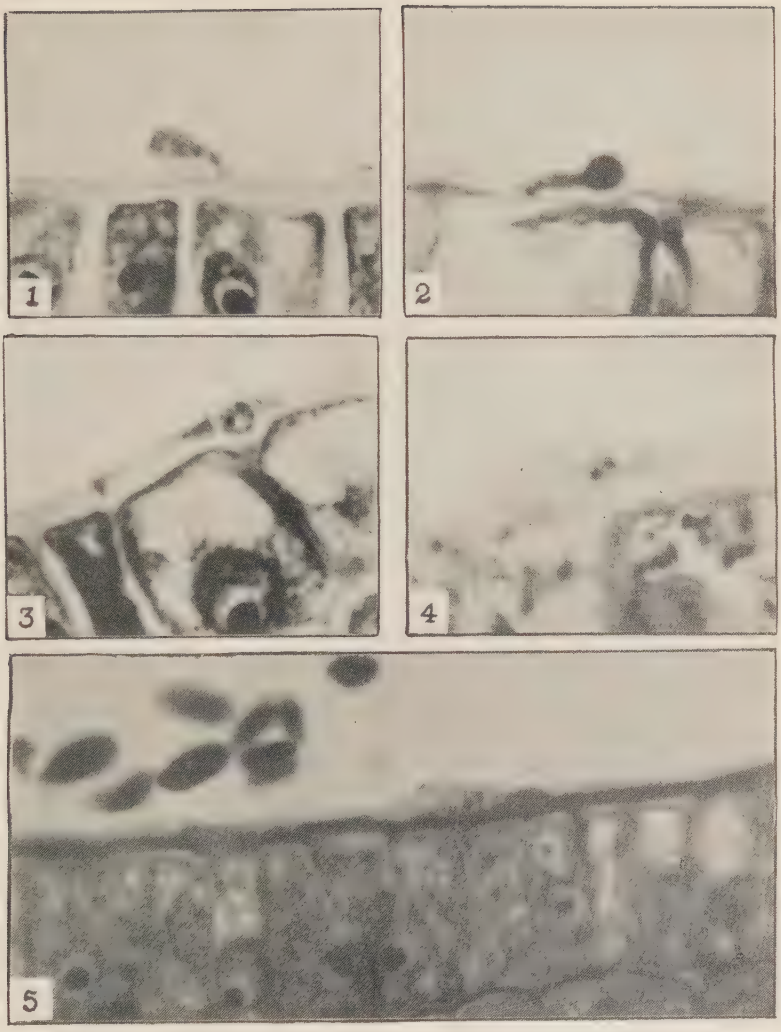

PLATE I.

1 and 2. The initial stages of penetration by *T. deformans*. Stained with iron alum haematoxylin. X1960.

3 and 4. Intracuticular mycelium showing nuclei. Stained with iron alum haematoxylin. X1960.

5. Intracuticular mycelium stained with Flemming's triple stain. X1400.

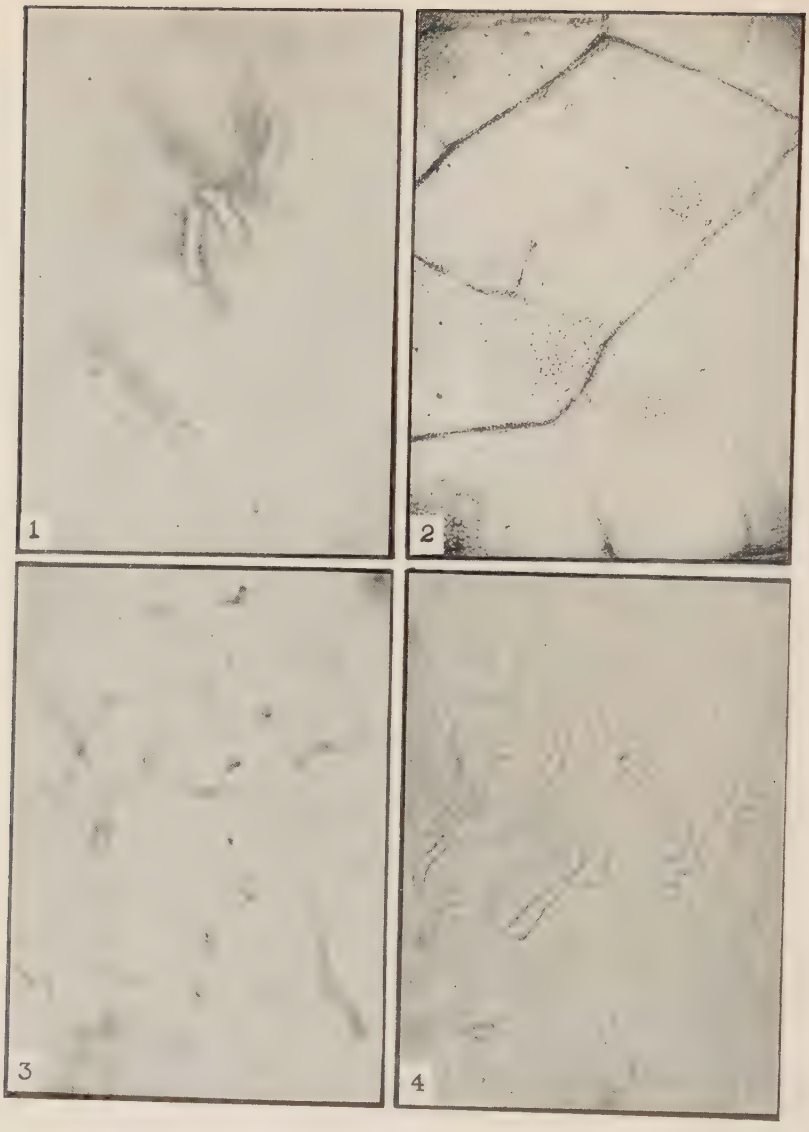

PLATE II.

The mycelium of *T. deformans* at various stages of development from leaves cleared in lactophenol.

1. The early stages of infection, showing intracuticular mycelia developed from six separate infections. X800.

2. The spread of the mycelium from a number of points of infection. X100.

3. The mycelium during the initial stages of its invasion of the mesophyll. X1200.

4. A later stage than 3 just prior to the formation of ascogenous hyphae. X400.

The mycelium now begins to increase in thickness. The hyphal walls can be readily seen in material which has been cleared in lactophenol and cross septa are laid down dividing the irregular strands into fantastically shaped cells (Plate II Figure 4). Soon hyphal branches make their way up between the epidermal cells to form a network of short thick cells beneath the cuticle. The asci are formed by the upward elongations of these cells which, as they grow, push through the cuticle forming a more or less continuous layer over the diseased area. The formation and discharge of the ascospores follows immediately, after which the leaves soon drop from the tree.

THE NUCLEAR SITUATION

In 1894 Dangeard (*3*) demonstrated that the ascongenous cells of *Taphrina deformans* are at first binucleate, but, as the ascus is formed, the two nuclei fuse to give a single large diploid nucleus which by reduction division produces eight haploid nuclei, around which the ascospores are cut out. Moreover, the binucleate condition found in the young ascogenous cells extends back into the vegetative hyphae where each cell exhibits one or more pairs of nuclei. When and where this binucleate condition arises has remained an open question. Eftimu and Dangeard have claimed that at the time of infection the single nucleus of the spore divides to produce two nuclei, both of which pass into a germ tube, thus initiating the binucleate condition in the infecting hypha. Wieben and Mix, on the other hand, claim that it arises through the copulation of two spores, the nucleus of one spore passing into the other and this they claim, may take place in culture.

The nuclear situation in the budding conidia from cultures was invertigated in the following manner. The spores were placed in a drop of formalin-acetic-alcohol on a flamed slide and the drop allowed to dry at room temperature. The slide was then washed for half an hour with distilled water and stained in the usual way with iron-alum haematoxylin. In young cultures the cells are for the most part uninucleate but some, which are budding, show two nuclei, one of which would have passed into the daughter cell (Figure 6, 1-4). As the culture becomes older and growth is retarded more of these binucleate cells appear. The long hypha-like cells found in old cultures usually possess more than one nucleus but the arrangement of these nuclei in no way suggests a true dicaryon condition since they often occur at opposite ends of extremely long cells (Figure 6, 12-15). Sprout conidia derived from mixed cultures exhibit precisely the same variations in nuclear condition as do those derived from single ascospores. Since in the monospore cultures all of the cells are the progeny

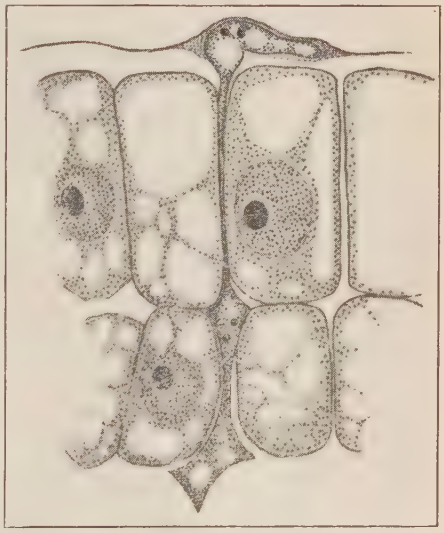

FIGURE 8. Cross section showing the binucleate condition in the intracuticular and initial intercellular mycelium.

of a single ascospore the presence of two nuclei in some of the cells cannot be due to copulation between genetically different spores as has been postulated by Mix (9).

The spores found on the surface of leaves exhibit the same nuclear phenomena as do those which have been grown on artificial media. For the most part they are uninucleate although a few have been observed with two nuclei. In the limited number of instances where the nuclear details could be observed at the time of penetration the nucleus appeared to have divided prior to the passage of the spore contents into the cuticle. The intracuticular mycelium always possesses at least one pair of closely associated nuclei (Figure 7 and Plate I, Figures 3, 4 and 5). As the fungus grows down between the epidermal cells to establish itself in the parenchyma tissue below, these two nuclei divide, giving rise to other pairs. Thus the binucleate condition of the mycelium is established at the outset of parasitic relationship (Figure 8).

Discussion

Originally *Taphrina deformans* was thought to be perennial in infected buds and although the advent of spraying has shown that this can hardly be so, since a single spray applied in the spring before the buds have opened will control the disease, no description of the progress of infection has hitherto been presented, nor has the form in which the fungus passes the winter been determined. The results of this investigation have supplied much of this information and we can now present an adequate description of its life cycle.

The ascospores which are discharged in the early summer, or the sprout conidia derived from them, lodge on the surface of the trees during the summer, fall, and winter but do not cause infection until the following spring, at which time, if they are washed to the opening leaf buds, and conditions of moisture and temperature are suitable, the young leaves become infected. The infecting spore produces a short peg-like hypha which attaches itself to the surface of the young leaf. The contents of the spore pass through this infection hypha into the cuticle where a limited growth occurs before further penetration takes place. From the cuticle the fungus makes its way between the epidermal cells and spreads out in the closely packed parenchymatous tissue below. The host cells in contact with the hyphae are stimulated and enlarge enormously so that the invaded area is more or less uniformly hypertrophied with the cells so closely packed that no intercellular space, other than that occupied by the fungus, remains.

It is doubtful whether the fungus ever spreads from a single point of infection to invade the entire leaf. In all of the material examined in which the entire leaf was infected there had obviously been several points of entry and, more often than not, these appeared in groups at different places on the surface of the leaf. The precise point in the ontogeny of the leaf at which the fungus within the leaf ceases to invade healthy tissue was not determined but it occurs at some time during the early stages of palisade and spongy parenchyma differentiation, prior to the separation of the cells in the latter to give inter-cellular spaces.

The ascus initials are formed subcuticularly at the time of maturation of the leaf and the asci which develop discharge their spores immediately so that the entire cycle from the time of infection to the time of spore discharge

takes but a few weeks. After the spores are discharged the fungus dies and the diseased portions of the leaf become quite flaccid. In all cases except those in which small areas of the leaf are diseased the leaves drop from the tree soon after.

There is no evidence that the fungus ever becomes perennial in the attacked twigs. The ascospores, or sprout conidia which form from these, live through the summer and winter lodged in the crevices of the bark and upon the scales of the dormant buds. Possibly they may also persist in the soil especially as it has been shown that they can remain viable in dry sterile soil for more than a year. Since the spores bud quite readily in very dilute nutrient solutions and large numbers of budding conidia were found in all of the material collected in the spring for sectioning, it seems altogether likely that a certain amount of growth is made whenever the trees are wet with rain for any extended period. This, together with the experimental evidence that the sprout conidia can survive under extremely dry conditions for more than a year, makes it most probable that the spores of *Taphrina deformans* actually become part of the normal surface flora of peach trees in districts where leaf curl is present. Indeed it is difficult to explain on any other basis the almost universal occurrence of the disease in a year immediately following one in which virtually no leaf curl developed. For example, in the year 1930 it was difficult to find curled leaves in the unsprayed orchard which was used in the following year for the spraying experiments. Yet, in 1931, with the exception of the sprayed trees, this entire orchard was uniformly and severely diseased. Since each diseased area on a leaf is caused by the infection from at least one spore the distinctly limited amount of inoculum which was liberated in 1930 could not possibly have caused such a severe outbreak in 1931 had not this increased enormously during the interval. This increase is probably to be accounted for by saprophytic development of sprout conidia on the trees in exactly the same way as occurs in the wild yeasts. While one hesitates to carry this analogy too far, the striking similarity between the behaviour of the budding spores of *T. deformans* and the cells of the wild yeasts and related organisms makes it easy to see how some of the latter may have arisen from somewhat similar parasites whose hosts have become exterminated during the process of evolution or have developed complete immunity to their attack.

The ability of the sprout conidia to bud and multiply upon the surface of the trees explains to some extent the erratic results which sprays give in very wet seasons. For unless all the spores on the entire tree are killed by the fungicide they are likely to be carried from the parts of the tree which the spray has not covered to the sprayed portions, where, if the rains have been heavy, most of the fungicide will have been washed away. Reasoning thus the results obtained in 1932 from the spraying experiments can be quite readily explained. The best control was given by the spray applied on April 27, at which date the buds were beginning to open but no infection had occurred, whereas the sprays applied before and after this were decreasingly efficient (Table 3). As the chart in Figure 5 shows, heavy rains fell in the early and middle part of April and these undoubtedly washed away part of the fungicide from the limbs which had been sprayed prior to their occurrence and at the same time carried fresh inoculum to these from the unsprayed

limbs. Although the experimental material used in 1932 was particularly favourable for demonstrating this type of spread, since there were a number of unsprayed branches on each tree, the same principle would operate to a greater or lesser extent in any orchard in which the dormant spray had not been thoroughly applied. The sharp decrease in the efficiency of the sprays applied after April 27 is due to infections occurring before the spray applications were made. The two factors therefore which govern the efficiency of a spray in a given season are the thoroughness with which the spray is applied and the time which elapses between the date of its application and the period favourable to infection. Because of this it is obvious that thoroughness is of greater importance in fall spraying than in spring applications because the spores which are not killed have a much longer period in which to multiply and spread than is the case with those missed by an application made in the spring.

In both 1931 and 1932 the sprays applied after the period during which most of the infection is presumed to have occurred were more effective in controlling the disease than was expected. Thus in 1931 the spray of April 29 controlled more than one-half of the infection which developed that year, although the most extended period of cold wet weather which occurred that spring immediately preceded the application of this spray. Likewise in 1932, although by far the most extended cold wet period was from May 6 to May 12, the spray of May 12 reduced the incidence of curl by one-half. These results at once suggest that the fungicide can reach and inhibit the fungus during the early stages of the infection process. The material which was collected on May 12, 1932, showed the fungus in all stages of its early development, ranging from the early stages of penetration to a number of well established infections which were beginning to have their effect upon the cells of the host. There were also a large number of infections at the intracuticular stage and it seems quite possible that the fungicide was able to diffuse through the very thin layer of cuticle surrounding those and inhibit their development. The fact that peach foliage is very susceptible to lime sulphur injury renders this hypothesis all the more probable.

Although the problem of why leaf curl infection should occur only in the spring and not throughout the summer is unsolved as yet, the data obtained from this investigation and from work now in progress suggest at least one reasonable explanation other than that penetration is limited by unfavourable external conditions. The fact that the fungus does not spread in the leaf after the latter has reached a certain stage in its ontogeny suggests that, as the peach leaf matures, its tissues develop a definite resistance to attack and this might explain why well-developed leaves never become diseased. This does not, however, account for the apparent resistance of the leaves which are developing during the summer from the tips of the shoots, since these must all pass through developmental stages comparable to those experienced by leaves which develop in the spring. Still it must be remembered that the leaves in the summer go through their development much more quickly than do the leaves which are formed in the early spring and it may be that the period of their susceptibility is passed before infection

can become established. This phase of the problem is receiving further attention.

The nuclear cycle of *Taphrina deformans* is of special interest in view of the emphasis at present being placed upon nuclear behaviour as one of the main considerations in determining phylogenetic relationships among the fungi. Morphologically the genus Taphrina displays characters which have caused it to be considered a primitive one among the Ascomycetes. The fruiting structure in particular is unspecialized as compared with the apothecium of the Discomycetes and the perithecium of the Pyrenomycetes. Nevertheless the work of Wieben (*10*) has indicated that cytologically there is a very highly developed type of life cycle in this group. Wieben has described the nuclear cycle in *Taphrina epiphylla* and *T. Klebahni* as follows. The ascospores are uninucleate and haploid, these bud in nutrient solutions producing sprout conidia which are also uninucleate, the sprout conidia of the third or subsequent generation copulate, the nucleus of one passing into the other cell but not fusing with the nucleus of it. This binucleate cell then germinates to produce a long septate germ tube (*suchfaden*), to the tip of which the associated nuclei move without dividing. Wieben believes that this germ tube is the infection hypha and that the dicaryon condition of the mycelium arises from the division of the two nuclei at its tip. Karyogamy occurs just prior to the formation of the ascus and is immediately followed by meiosis which gives rise to the eight haploid ascospores. Now, as Kniep (*4*) has pointed out, cytologically this is essentially similar to the condition obtaining in *Ustilago violacea* where the sporidia copulate prior to infection and the mycelium within the host is binucleate. This may be illustrated graphically as shown in Figure 9.

This investigation has shown that in *Taphrina deformans* the nuclear cycle differs from that presented by Wieben for *T. epiphylla* and *T. Klebahni*, since in *T. deformans* no copulation occurs prior to infection and the binucleate condition is brought about simply by the division of the haploid nucleus of the spore at the time of infection to give a pair of nuclei. The contents of the spore pass into the cuticle of the host and then these two nuclei divide conjugately giving rise to other pairs thus giving rise to the binucleate mycelium. The nuclear situation in *T. deformans* is therefore quite comparable to that of a short-cycle rust of the *Puccinia malvacearum* type, in which, as Ashworth (*1*) has shown, the diploid phase is initiated directly from haploid mycelium derived from monobasidiospore infection. The nuclear situation in *Taphrina epiphylla* and *Ustilago violaceae* is essentially the same as that of a long-cycled rust of the *Puccinia graminis* type, for two haploid spores of opposite potentiality are needed before these fungi can complete their life cycle. Therefore if *P. malvacearum* is, as Jackson (*5*) suggests, a reduced form of rust from the long-cycled type, we are justified in suggesting that the same process of evolution which is occurring in the rusts may be likewise occurring in the genus Taphrina of the Ascomycetes, and that *T. deformans* represents a short-cycled form evolved from the long-cycled *T. epiphylla* type. In *T. epiphylla* and *U. violaceae*, as in the long-cycled rusts though sexual structures are eliminated or extremely reduced, a provision for hybridity is retained. In *T. deformans* and *P. malvacearum* hybridity has been lost and each haplont becomes self-fertile (Figure 10).

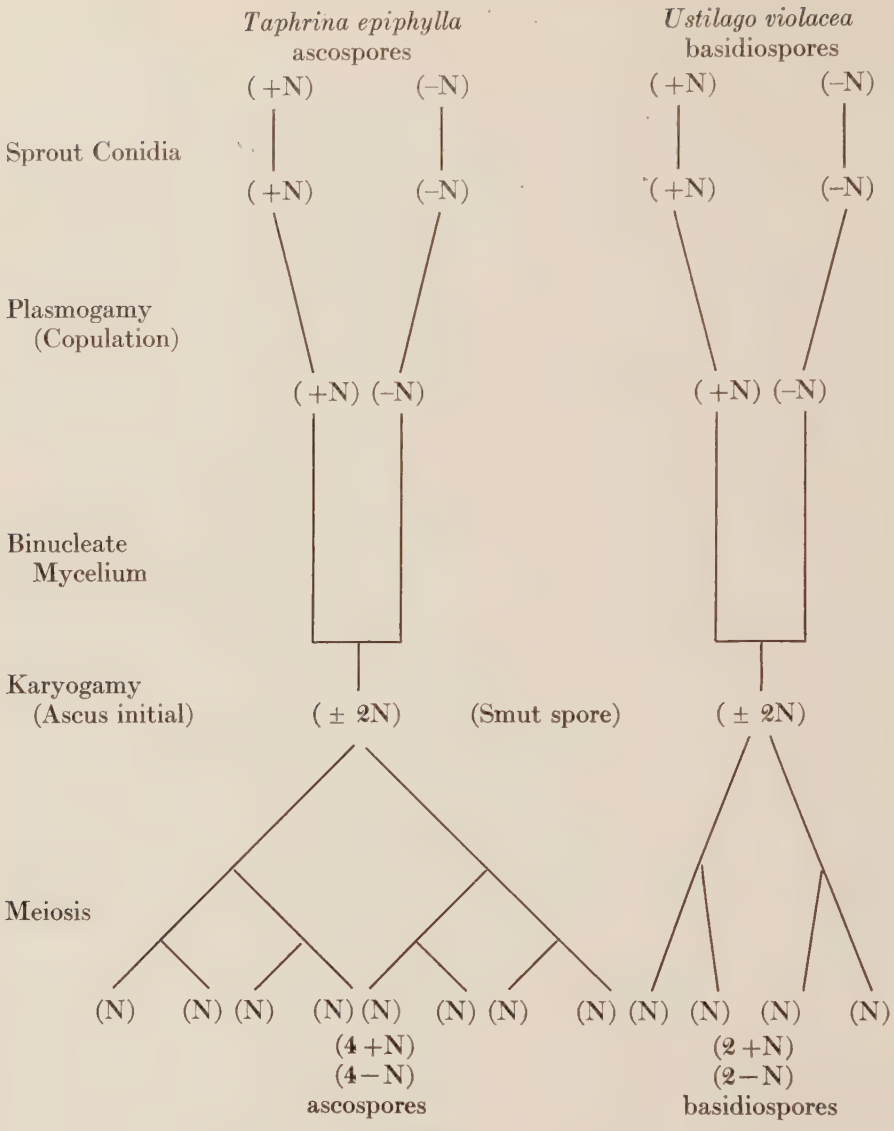

Figure 9

Summary

1. The life history and parasitism of *Taphrina deformans* have been investigated.

2. Carefully timed spraying experiments indicate that infection occurs in the spring just as the leaf buds are unfolding. In the Niagara district summer infection rarely, if ever, occurs.

3. The ascospores or sprout conidia derived from them have been shown to persist through the summer and winter lodged on the twigs and buds of the peach. From there they are washed to the opening leaf buds by the spring rains.

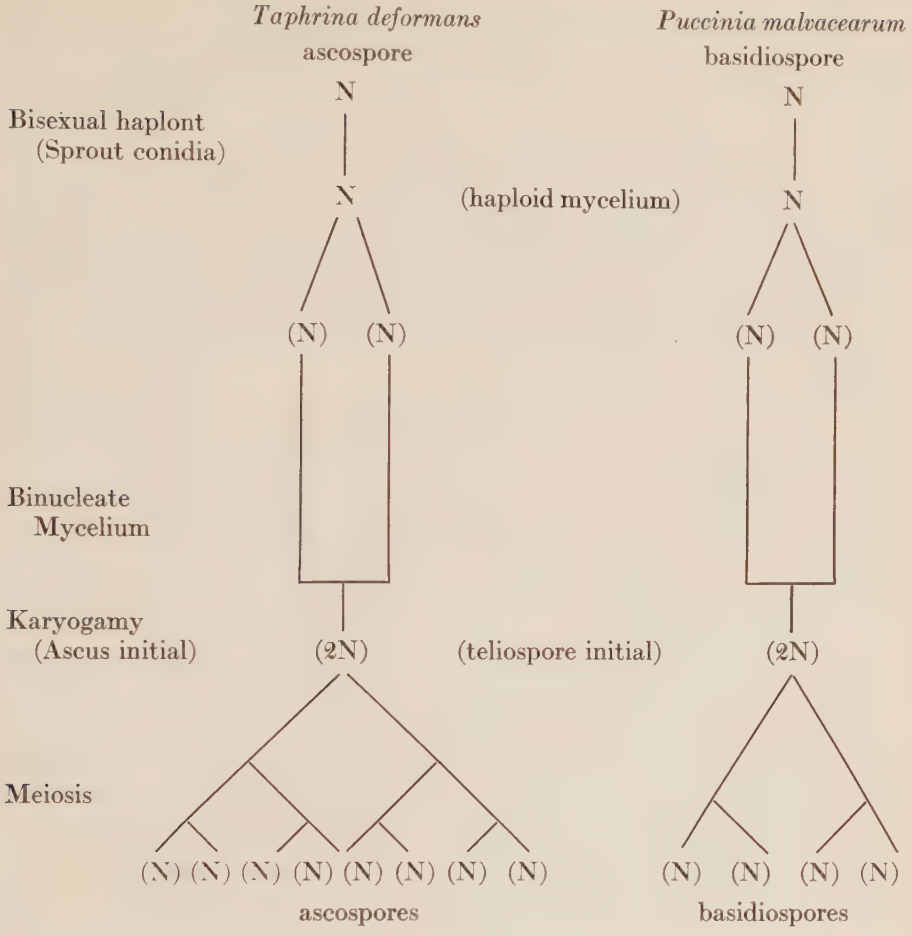

Figure 10

4. Penetration may occur from either surface of the leaf. A spore about to initiate infection produces a short hypha which attaches itself to the leaf surface, and the contents of the spore pass through this into the cuticle where a limited growth is made.

5. From the cuticle the fungus penetrates between the epidermal cells, and for a time grows out in all directions among the parenchyma cells below.

6. The mycelium is irregular and at first is very thin and without septa but later becomes much thicker and numerous cross walls are laid down.

7. Invaded tissues become hypertrophied, the response being apparently confined to the cells in contact with the mycelium.

8. The spores possess a single haploid nucleus which divides as the bud is being formed and the daughter nucleus migrates into the bud. When infection occurs this daughter nucleus appears to assume a conjugate relationship with the mother nucleus and both migrate into the penetration tube. Subsequent divisions are conjugate and one or more pairs of nuclei are found in each cell when the mycelium becomes septate. Thus the entire life cycle

can be initiated by a single spore and no copulation of sprout conidia such as has been reported for *Taphrina epiphylla* and *T. Kelbahni* occurs in this species.

ACKNOWLEDGEMENTS

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THE NECESSITY FOR GROWING LEGUMES ON GRAY WOODED SOILS

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The prairie provinces of Canada have vast areas of gray wooded soils similar to those found in Alberta. Results obtained by the use of legumes and fertilizers on such wooded soils in Alberta should be of interest to scientists and farmers in other districts where similar soils occur. The following results report experiments for the years 1930 to 1933 carried out on the Breton Experimental Field[2].

The soil is typical of the gray wooded soil belt of Alberta, and has been previously described (*3*, *4*, *5*). These soils are of relatively low initial fertility and do not possess the most desirable physical properties owing to their great tendency to bake when dry. They have suffered considerably from leaching (*1*, *2*), and are likewise of a low order with respect to their phosphorus and nitrogen content. As a consequence, satisfactory crop yields are seldom obtained except, possibly, for the first year following a good fallow, and even then the yields are not as great as from the more fertile soils.

On the other hand these soils are not sufficiently acid to prevent the growth of any of the legumes, but much better growth is obtained with fertilizers, especially in cases where nitrogen and phosphorus are applied. No difficulty has been encountered in obtaining splendid inoculation with the legumes. At the same time we have always obtained very good increases whenever nitrogen has been applied to the legumes as well as to the cereals.

The greater part of the yield data from our experiments with the wooded soils is omitted from the present discussion. However, the following results are sufficient to show the great value and necessity of growing legumes and applying fertilizers if the poorer wooded soils are to be made sufficiently fertile to produce satisfactory crop yields. Part of the yields from Series A. B. C. D and E of the Breton Experimental Field are reported in the following tables. Each series consisted of 11 plots treated as follows:

Plot	1	Check
"	2	Manure
"	3	Nitrogen, phosphorus and potassium.
"	4	Nitrogen
"	5	Check
"	6	Lime
"	7	Lime and phosphorus
"	8	Phosphorus
"	9	Manure and phosphorus
"	10	Nitrogen and phosphorus
"	11	Check

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[2] Grateful acknowledgement is made to other members of the Soils Department who assisted in the experiments herein reported.

The applications of the manure and of the lime were made every alternate year, whereas the other fertilizers were applied annually. The fertilizers were applied with the drill, but across the grain rows and not with the seed. Direct application with the seed would be better practice.

The first four series consist of a rotation of legumes to be plowed under, wheat following legumes, oats following wheat, barley nursing legumes; whereas Series E is wheat grown continuously except when necessary to fallow for weed control.

Oats were grown on the entire field in 1929. Thus the different rotation crops in 1930 all followed oats. The legume crop to be plowed under (Series A) in 1930 consisted of field peas. Barley nursing clovers was grown on Series B, oats on Series C, wheat on Series D and E.

Yields of Clover Hay

The yields of clover hay grown and plowed under for the three years (1931 to 1933) are reported in Table 1.

It will be seen that some fertilized plots doubled, or, in some cases, tripled the yields obtained from the check plots. The fertilizers, with the exception of manure, gave decided increases in yield. The manure gave only slight increases during the first two years, but for 1933 after the second application had been made the yield of the manured plot was double that of the checks. The average increase in yields for the manured plots for the three years was a little over 1/3 of one ton. Lime alone has given increases for the clovers of more than ¾ of a ton. The increases for the other fertilizers have all been from 1¼ to 1½ tons. In general there has been a slight tendency for the yields on the fertilized plots to increase between the years 1931 and 1933. The lime plot, however, gave a smaller yield in 1933

TABLE 1.—YIELDS OF MIXED CLOVER HAYS* AND INCREASES FOR FERTILIZERS. BRETON EXPERIMENTAL FIELD (1931-33)

Plot	Fertilizer treatment	Clover hay. Lbs. per acre			Average yield for 3 years	Average increase for 3 years	Lbs. N. plowed under in clover crops Ave. 3 years
		Series B 1931	Series C 1932	Series D 1933			
1, 5, 11	None	1922	1703	1678	1768	—	36.2
2	M	2208	1665	3495	2456	688	50.9
3	NPK	3822	4395	6085	4767	2999	144.0
4	N	5140	3160	4380	4227	2459	91.3
6	L	3574	3835	2736	3382	1614	68.0
7	LP	4087	4515	4550	4384	2616	101.3
8	P	4055	4230	4495	4260	2492	92.9
9	MP	4047	4510	5460	4672	2904	103.3
10	NP	3734	4220	6020	4658	2890	105.3

* Series B. and C consisted of a mixture of sweet clover and alsike clover, whereas Series D was sweet clover and altaswede (red clover).

than in either of the previous two years. The clovers were grown on these plots only once, but each plot had received fertilizers, as previously stated, every year from 1930 to 1933 with the exceptions of the manure and the lime plots, in which cases these fertilizers were applied only twice during this same period. The average yields of clovers from the last four plots (7 to 10) for the three years were about equal. However, in connection with the subsequent grain yields from these same plots it will be seen at a later point that the yield from the phosphorus plot (Plot 8) was decidedly less than any of the other three plots just mentioned. When crops of the magnitude of those reported in Table 1 are plowed under it is to be expected that there would be varying results in subsequent grain crops, since the clovers plowed under contained different quantities of plant foods. This is indicated in the last column of the table, which shows that the check plots contained only 36 pounds of nitrogen (in the clover) when compared with the higher-yielding clover plots which contained upwards of 100 pounds of nitrogen.

Yields of Wheat, Oats and Barley

The turning under of legume crops has given decided stimulus to the succeeding crops, and the best results were obtained in such practices as the incorporation of a part or all of the legume crop, together with the application of fertilizers. Certain of the fertilizers gave very good increases when applied to cereals following cereals, but the response was much greater for these fertilizers when they were used as supplements to the clovers. All fertilizers when used in conjunction with the clovers gave good responses, but some of the fertilizer treatments were not economical when used in the absence of clovers. The turning under of clovers alone gave fairly good responses, but turning under of clovers was several times more effective when in conjunction with the use of fertilizers. The use of fertilizers alone or of clovers alone was not adequate for the production of maximum crop yields. However, in the practice of the combined use of fertilizers and the plowing under of clovers, the yields obtained were of the same order as those obtained from the black soil areas. The above practice doubled the productive power of the wooded soils, and the value of clover was of the same order as that of the fertilizers.

Wheat yields after oats, after fallow, and after clover plowed under, are reported in Table 2.

The yields of wheat after oats were from 8 to 19 bushels less per acre than wheat after fallow for similarly treated plots, whereas the yields of wheat after oats were from 11 to 31 bushels less than wheat after clover plowed under, with the exception of the check plots. Similar comparisons might be made for wheat after fallow. This gives some idea of the effect of the fertilizers when wheat follows oats, wheat follows fallow and wheat follows the plowing under of clovers. The individual increases for fertilizers in each of the above three systems are also reported in Table 2, where it will be seen that in the case of wheat after oats only two of the fertilizers gave increases of the order of above 9 bushels per acre, compared with four of the fertilized plots in the wheat after fallow series, which gave increases of approximately 13 bushels per acre, and five of the fertilized plots in the wheat after clover system gave increases of 20 bushels or more per acre, with the other three fertilized plots giving increases of over 8 bushels. It will be seen also that the check plots under the fallow system out-yielded the check

TABLE 2.—YIELDS OF WHEAT AFTER OATS, WHEAT AFTER FALLOW, WHEAT AFTER CLOVER PLOWED UNDER; AND INCREASES FOR FERTILIZERS. BRETON EXPERIMENTAL FIELD (1930-1933)

Plot	Fertilizer treatment	Wheat yields. Bus. per acre			Increases for fertilizers. Bus. per acre		
		Wheat after oats 1930	Wheat after fallow 1933	Wheat after clover plowed under 1933	Wheat after oats 1930	Wheat after fallow 1933	Wheat after clover plowed under 1933
1, 5, 11	None	15.4	25.0	19.8	—	—	—
2	M	14.7	27.8	28.8	- .7	2.8	9.0
3	NPK	25.3	38.7	46.3	9.9	13.7	25.5
4	N	19.6	38.2	40.0	4.2	13.2	20.2
6	L	17.0	27.5	28.4	1.6	2.5	8.6
7	LP	17.5	33.0	39.8	2.1	8.0	20.0
8	P	17.5	25.6	32.9	2.1	0.6	13.1
9	MP	19.0	37.9	47.3	3.6	12.9	27.5
10	NP	24.5	37.7	55.4	9.1	12.7	35.6
Vertical averages					4.0	8.3	19.9

plots where the clovers had been plowed under. However, the increases due to fertilizers were in all cases materially greater for the series where clover had been plowed under. The increases for the lime treatment (Plot 6) and for the phosphorus treatment (Plot 8) are of a very small order, both in the series where wheat follows oats and where wheat follows fallow, but both of these treatments have given significant increases where wheat follows clover plowed under.

A somewhat better idea of the effectiveness of fertilizers in the above systems may be obtained by comparing the vertical averages for the fertilizer increases, where it will be seen that the average increases of all the fertilizer treatments in the wheat after oats system amounted to 4 bushels of wheat per acre. A similar figure for the wheat after fallow was 8.3 bushels, whereas wheat after clover plowed under showed average increases for the fertilizer treatments amounting to 19.9 bushels.

From the above wheat yields the following significant fact is brought out. The best fertilizer treatments where wheat followed oats gave yields of the order of 25 bushels of wheat per acre, whereas the best fertilizer treatments after clover had been plowed under gave wheat yields of the order of 45 to 55 bushels per acre. Thus the yields of wheat have been doubled with the plowing under of only one crop of clover and the use of fertilizers.

Similar results are shown for the oat and barley crops. The yields for these two crops are reported in Table 3.

Here it is seen that the oat crop grown the second year after clovers had been plowed under gave yields in all cases much greater than oats after

oats, and in some cases the yields were more than doubled, thus showing that the residual effect of the plowed-under clovers had been maintained well into the second year. The important effect of the plowing under of clovers is likewise shown in the comparison of the barley yields with yields from similarly treated plots where barley followed oats. The data show that where oats followed oats three of the fertilizer treatments gave increases of the order of 14 to 17 bushels, and where oats were grown the second year after the clovers had been plowed under, five of the fertilizer treatments gave increases varying from about 18 to about 49 bushels. Similarly barley after oats showed three of the fertilizer treatments giving increases from about 12 to about 20 bushels, whereas when barley followed clover plowed under, six of the eight fertilized plots gave increases varying from 17 to 41 bushels.

The effect of the increase of the fertilizers after clovers had been plowed under as compared with the cereals following cereals is shown in another manner by the vertical averages. Here it is seen that the average effect of all the fertilizer treatments on oats after oats was equivalent to 8.9 bushels increase, whereas the average effect for oats (second crop) after clovers had been plowed under was 22 bushels. The corresponding figures for the barley crop were 8.7 and 23.9 bushel increases respectively.

Responses to the use of fertilizers and clovers on these wooded soils are clearly shown by the relative yields from the various plots of wheat following clover (Figure 1).

TABLE 3.—YIELDS OF OATS AND BARLEY AND INCREASES FOR FERTILIZERS. BRETON EXPERIMENTAL FIELD (1930-1933)

Plot	Fertilizer treatment	Oat yields Bus. per acre		Increases for fertilizers Bus. of oats		Barley yields Bus. per acre		Increases for fertilizers Bus. of barley	
		Oats after oats 1930	Oats after wheat after clover plowed under 1933	Oats after oats 1930	Oats after wheat after clover plowed under 1933	Barley after oats 1930	Barley after clover plowed under 1933	Barley after oats 1930	Barley after clover plowed under 1933
1, 5, 11	None	27.1	41.2	—	—	22.3	27.5	—	—
2	M	25.3	50.1	−1.8	8.9	22.5	46.2	0.2	18.7
3	NPK	44.3	62.2	17.2	21.0	42.5	68.6	20.2	41.1
4	N	44.7	90.3	17.6	49.1	33.9	51.2	11.6	23.7
6	L	32.9	50.7	5.8	9.5	27.1	39.0	4.8	11.5
7	LP	36.3	58.9	9.2	17.7	24.6	44.7	2.3	17.2
8	P	32.9	50.1	5.8	8.9	27.3	39.5	5.0	12.0
9	MP	30.4	66.2	3.3	25.0	29.2	58.3	5.9	30.8
10	NP	41.5	77.0	14.4	35.8	42.2	63.8	19.9	36.3
Vertical averages				8.9	22.0			8.7	23.9

Figure 1. Each bundle represents 4 sq. yds. The differences in yields (see Table 2) vary from 19.8 to 55.4 bushels.

Figure 2. Mixture of sweet and altaswede clover 1933. The check plot yielded 1726 lbs. whereas the nitrogen plot yielded 4380 lbs.

Value of Clover Plowed Under

The effect of the various fertilizers as expressed by increased yields of wheat, oats and barley with and without clover plowed under, has been shown in Tables 2 and 3. These data, however, did not set out the specific effect of clover. The increases caused by clover may be obtained by comparing horizontally the yields from similarly fertilized plots. Such comparisons are shown in Table 4 where each increased yield represents the superiority of clover over the series without clover.

TABLE 4.—INCREASED YIELDS OF WHEAT, OATS AND BARLEY DUE TO CLOVER PLOWED UNDER AS COMPARED WITH WHEAT, OATS AND BARLEY FOLLOWING OATS AND WHEAT FOLLOWING FALLOW (BUS. PER ACRE INCREASE)

Plot	Fertilizer treatment	Increased yields (bus.) of wheat due to clover plowed under		Increased yields (bus.) of oats (2nd crop) due to clover plowed under	Increased yields (bus.) of barley due to clover plowed under
		Compared with wheat after oats	Compared with wheat after fallow	Compared with oats after oats	Compared with barley after oats
1, 5, 11	None	4.4	−5.2	14.1	5.2
2	M	14.1	1.0	24.8	23.7
3	NPK	21.0	7.6	17.9	26.1
4	N	20.4	1.8	45.6	17.3
6	L	11.4	.9	17.8	11.9
7	LP	22.2	6.8	22.6	20.1
8	P	15.4	7.3	17.2	12.2
9	MP	28.3	9.4	35.8	29.1
10	NP	30.9	17.7	35.5	21.6
Vertical averages		18.7	5.3	25.7	18.6

The plowing under of clover has been superior to the other systems in every case, with the single exception of the check plots on fallow. The value of clover has been much greater when compared with the wheat after oats than when compared with the wheat after fallow, but the plowing under of clover has given greater yields than fallow for every fertilizer treatment; as an average of all the fertilized wheat plots the clover has given 6.3 bushels more than the fallow and 20.5 bushels more than the wheat after oats. The corresponding figures for the increases due to fertilizers in the above two systems are 8.3 and 19.9 bushels respectively. The value of clover as measured by the increased oat yields has varied from 14 bushels for the check plot to almost 46 bushels for the nitrogen plot (Plot 4). Similarly the increases in barley due to the clover varied from 5.2 bushels for the check to 29.1 bushels for the manure and phosphorus plot (Plot 9).

It should be kept in mind that the increases shown in the oat yields are those which have carried over into the second year after the clover had been plowed under. Thus we are justified in adding the increases in oat yields to the increases in wheat yields (column 1) as indicating the value of the plowed-under clovers. It is too early to say whether or not the effect of the plowed-under clover will be carried over into the third year.

It will be seen that the increases due to the clover are approximately of the same magnitude as the increases due to the fertilizers previously discussed. It should again be pointed out that the increases due to the clover alone, where fertilizers had not been applied, were of the same order as the increases due to the fertilizers alone without clover plowed under. However,

the value of the fertilizer and of the clover was materially increased when these were used jointly. This is to be expected, since as previously shown in Table 1, the amount of clover plowed under was largely dependent upon the fertilizer used.

If the average increases for fertilizers, as shown in Tables 2 and 3, and the average increases for clovers obtained from the fertilized plots shown in Table 4, are brought together in a summary table, a more comprehensive idea is obtained of the relative effects of fertilizers and of clovers. Such a summary is shown in Table 5.

TABLE 5.—INCREASES OF WHEAT, OATS AND BARLEY FOR FERTILIZERS AND FOR CLOVER PLOWED UNDER; BRETON EXPERIMENTAL FIELD
(Increases reported as bushels per acre)

	Wheat			Oats		Barley	
Average increases for all fertilizers (Vertical averages from Tables 2 & 3)	Wheat after oats 1930	Wheat after fallow 1933	Wheat after clover plowed under 1933	Oats after oats 1930	Oats (2nd crop) after clover plowed under 1933	Barley after oats 1930	Barley after clover plowed under 1933
Increases for fertilizers (Bus. per acre)	4.0	8.3	19.9	8.9	22.0	8.7	23.9
Comparisons of check with and without clover, also fertilized plots with and without clovers	Clover checks over checks without clover	Clover and fertilizers over fallow and fertilizers	Clover and fertilizers over fertilizers without clover	Clover checks over checks without clover	Clover and fertilizers over fertilizers without clover	Clover checks over checks without clover	Clover and fertilizers over fertilizers without clover
Increases for clovers (Bus. per acre)	4.4	6.3	20.5	14.1	27.1	5.2	20.3

It is admitted that such a summary did not indicate the best fertilizers or the poorest fertilizers, and that the value of the least effective fertilizers was small, whereas the value of the more effective fertilizers was great. However, these average figures do show in general exactly the relative effect of fertilizers and clover when used alone and as influenced by each other. It is seen that clovers alone gave an increase of 4.4 bushels of wheat, 14.1 bushels of oats, and 5.2 bushels of barley, whereas fertilizers alone gave increases of 4.0 bushels of wheat, 8.9 bushels of oats, and 8.7 bushels of barley. When clovers were plowed under and fertilizers used in addition, the value of the clover gave the following increases: Wheat 20.5 bushels, oats 27.1 bushels, barley 20.3 bushels, whereas the increases for the fertilizers were respectively—wheat 19.9 bushels, oats 22.0 bushels, and barley 23.9 bushels.

Summary

Results are reported from the Breton Experimental field for the years 1930 to 1933 giving crop yields for clovers, wheat, oats and barley on the gray wooded soils of Alberta. In their virgin condition these soils are relatively infertile, but with the growth of legumes and the use of fertilizers they can be converted into relatively productive soils within the period of a few years.

With the exception of manure, all the fertilizers used gave decided increases in the clover yields. The average increase in yields for the manured plots for the three years was a little over 1/3 of one ton. Lime alone gave increases for the clovers of over ¾ of a ton. The increases for all other fertilizers have been from 1¼ to 1½ tons. The clovers were grown on each plot only once. The extreme variations in crop yields ranged from a little under a ton for the checks to approximately three tons for some fertilized plots. These clovers were plowed under in order to determine the effect upon the subsequent grain crops. The amount of nitrogen contained in the plowed-under clover varied from about 36 pounds for the checks to 144 pounds for the highest yielding plot.

The plowing under of clovers alone gave fairly good responses, but the plowing under of clovers was several times more effective when in conjunction with the use of fertilizers. The use of fertilizers alone or clovers alone was not adequate for the production of maximum crop yields. The practice of plowing under of clovers in conjunction with the use of fertilizers doubled the productive power of the wooded soils, and the value of the clover was of the same degree as that of the fertilizers.

The yields of wheat after oats were from 8 to 19 bushels less per acre than wheat after fallow for similarly treated plots, whereas the yields of wheat after oats were from 11 to 31 bushels less than wheat after clover plowed under. In the series of wheat after oats only two of the fertilizers gave increases above 9 bushels per acre, whereas four of the fertilized plots in the wheat after fallow series gave increases of approximately 13 bushels per acre, and five of the fertilized plots in the wheat after clover series gave increases of 20 bushels or more per acre. Similar increases were shown for the barley and oat crop. The effect of the plowed-under clover was maintained at least into the second crop year.

Such data bring out the fact that the plowing under of clovers and the use of fertilizers is of similar value and that both are absolutely necessary if satisfactory yields are to be obtained from these wooded soils. As a general statement covering all three grain crops the results might be expressed as follows: The increases in yields were from 2 to 4 times as great for both the clovers and the fertilizers when used conjointly as when used alone.

The necessity of legumes and the use of fertilizers for the wooded soils becomes apparent when it is remembered: first, that the use of fertilizers doubles the yields of clover; second, that the plowing under of clovers in conjunction with the use of fertilizers has more than doubled the yields of the grain crops, such as wheat, oats and barley; third, that the above increases in the grain crops have resulted from the plowing under of a single crop of clover.

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CAPITAL INVESTED PER SHEEP RANCH, IN THE MAPLE CREEK AND GREAT SANDHILLS AREA OF SOUTHWESTERN SASKATCHEWAN[1]

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It may be of interest for those unfamiliar with sheep ranching to know that the production of sheep under range conditions requires a rather heavy capital investment. This is clearly shown by examining the capital structure of sheep ranches in the Maple Creek and Great Sandhills Area of Southwestern Saskatchewan. There was found to be $35,542 invested on the average per ranch or $24.81 per head of sheep. Of this amount $14,337 was invested in land and $9,607 in sheep; these two items made up 67.4% of the total. It should be mentioned that these figures are for 18 ranches which had on the average 1,432 head of sheep per ranch. It is only reasonable to expect a wide variation in the distribution of the fixed capital invested on different ranches as indicated in Table 1. The average for all ranches, however, was found to be 40.4% invested in land, 27% in sheep, 13.5% in buildings and improvements, 7.5% in other live stock, 6.4% in machinery and equipment, and 5.2% in feed and supplies.

TABLE 1.—CAPITAL INVESTED PER RANCH; 18 SHEEP RANCHES MAPLE CREEK AND GREAT SANDHILLS AREA OF SOUTHWESTERN SASKATCHEWAN: AVERAGE 1929, 1930, 1931

Ranch No.	Value land	Value sheep	Value buildings and improvements	Value other live-stock	Value machinery and equipment	Value feed and supplies	Total investment
85	42,498	15,087	12,502	3,166	2,875	3,529	79,657
28	21,375	6,845	7,625	2,207	4,567	2,803	45,422
55	19,377	10,158	5,623	1,154	3,323	2,577	42,212
88	6,552	16,095	7,448	5,468	3,462	3,024	42,049
43	24,332	8,299	5,668	599	1,242	1,047	41,187
65	15,889	8,298	4,111	7,688	2,807	1,202	39,995
81	4,452	15,001	3,548	11,331	1,458	3,520	39,310
7	27,307	3,976	2,693	2,228	1,451	1,287	38,942
79	12,986	13,034	5,014	4,483	1,613	1,206	38,336
77	15,174	12,428	4,826	1,952	870	2,663	37,913
76	14,993	12,667	3,007	1,301	2,412	943	35,323
92	9,113	17,668	2,887	759	2,590	1,567	34,584
70	11,923	10,749	3,077	549	2,676	2,095	31,067
36	9,908	6,238	4,092	1,122	2,862	1,313	25,535
47	9,878	7,649	2,122	953	801	689	22,092
30	5,435	4,136	5,465	885	1,713	1,310	18,944
45	3,837	2,226	3,163	1,312	2,318	1,710	14,566
5	3,039	2,374	3,361	1,090	2,045	713	12,622
Average per ranch	$14,337	$9,607	$4,791	$2,680	$2,282	$1,844	$35,541
Per cent	40.4	27.0	13.5	7.5	6.4	5.2	100.00
Average capital per head	$10.01	$6.71	$3.34	$1.87	$1.59	$1.29	$24.81

The large investment in land was due to the rather high percentage of deeded land as compared with leased land. There was on the average 9,720 acres per ranch of which 1,751 acres or 18% was deeded land and 7,969 acres or 82% was leased land. Of the leased land 88% was Crown land, 5% school land, 3% Hudson's Bay, and 4% open free range.

[1] The conclusions presented in this preliminary article represent one section of an economic study dealing with various phases of the range sheep industry in Western Canada. The study was started in 1930 and is conducted jointly by the Agricultural Economics Branch and the Experimental Farms Branch of the Dominion Department of Agriculture.

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About fifty years ago when this area was first settled, all range was open and free but the sheep rancher under present conditions must either lease or purchase the land he requires. Much of it has a low carrying capacity which explains the need for such a large area per ranch. It required 5.4 acres per sheep unit on the average for all ranches. The insecurity of tenure in past years has resulted in ranchers purchasing certain lands especially those privately owned to give greater permanency to their business. This land for the most part was bought at a price above the value of such lands for grazing purposes. The value of deeded land averaged about $6.50 per acre without considering buildings and improvements. There is also a capital valuation for lease land since such lands are sometimes bought and sold. A 40 cent capital value per acre aside from improvements was found to be the average estimate given by ranchers for lease land. In some instances the lease was capitalized at the same as the value of the improvements.

Sheep on the range are not kept under woven wire or wolf-proof fence as is the custom in some parts of New Mexico and other southern central states, but are herded in bands of about 1,500. The ranch is generally fenced with two or three strands of barbed wire, which serves not only as a boundary, but also divides the ranch into pastures, and keeps out stray stock. Fencing is a heavy cost on a ranch and in addition to the initial outlay, it must be kept in repair. The value of all fences, buildings, dipping tanks, sheep sheds, barns, range water developments and other improvements was found to be 49 cents per acre on the average per ranch.

The ranchers do not follow the practice of keeping wether lambs for wool production as is the custom in certain sections of Australia and the Union of South Africa. The permanent flock of 1,432 head of sheep found on the average per ranch consisted of 76% breeding ewes, 21% ewe lambs and 3% ram lambs, cull wethers and rams. It should be explained that it is the practice on ranches to keep ewe lambs for replacement and expansion purposes, but they do not become part of the breeding flock until the fall of the second season at which time they are about one and one-half years of age.

On most ranches a few cows are kept for milking purposes and horses are used for riding and farm work although four of the 18 ranches included in this study had tractors.

One of the greatest problems of ranching is to obtain sufficient winter feed. The amount required depends on the snow covering. The native prairie hay is cut in low spots and specially conserved areas. A large amount of Russian thistle, a weed with a succulent stem, is also put up and if cut at the proper time makes suitable feed.

The capital invested in sheep in relation to land and other fixed assets had a marked effect on the income from ranching. The best distribution of capital included a large proportion invested in sheep.

RESUME

NECESSITE DE LA CULTURE DES LEGUMINEUSES SUR LES SOLS FORESTIERS GRIS. F. A. Wyatt, Département des Sols, Université de l'Alberta, Edmonton, Alta.

Du trèfle, du blé, de l'avoine et de l'orge ont été produits en rotation sur des sols forestiers gris avec l'aide d'engrais chimiques. A l'état vierge ces sols sont relativement infertiles, mais ils peuvent être rendus relativement fertiles en quelques années à l'aide de légumineuses et d'engrais chimiques. L'emploi d'engrais seulement ou de trèfle seulement ne suffit pas. L'augmentation de rendement du grain a été de deux à quatre fois plus grande lorsque le trèfle et les engrais chimiques ont été employés conjointement que lorsqu'on a utilisé seulement l'une ou l'autre amélioration. La pratique d'enfouir du trèfle et l'emploi d'engrais chimiques ont plus que doublé la productivité de ces sols forestiers.

THE ECONOMIC SITUATION

PREPARED IN THE AGRICULTURAL ECONOMICS BRANCH, DEPARTMENT OF AGRICULTURE, OTTAWA, FROM BASIC DATA COLLECTED BY THE DOMINION BUREAU OF STATISTICS

The upward trend of wholesale prices in Canada was maintained in December. The index rose fractionally from 68.7 to 69.0. Animals and their products, fibres, textiles and textile products, wood, wood products and paper, iron and its products, non-ferrous metals and their products and non-metallic minerals advanced. Vegetable products and chemicals and allied products were lower. The preliminary index for 1933 was 2.2 points higher than that for 1932; even more significant, however, has been the reasonably consistent strength shown during the latter months of the past year in wholesale markets.

Retail Prices. The index number of retail prices advanced from 78.1 in November to 78.4 in December. Higher indexes for food and clothing were responsible for the rise in the total index. In this connection it is worthy of note that retail sales on the whole showed improvement during the last five months of 1933. This indicates a growing confidence and to some extent a rise in purchasing power.

Employment. Employment conditions continue to improve. The index at January 1st, 1934, was 95.0 as compared with 91.8 at the beginning of December. The actual number of workers employed was slightly less than at December 1st but the seasonal decline was much less than usual and thus the adjusted index was higher.

Physical Volume of Business. The index number of the physical volume of business advanced from 85.5 in November to 86.2 in December. This was just 13.6 points above the December 1932 index. Industrial production was 17.4 points above the December 1932 index. During the past month, the index of manufacturing rose 2.4 points. Mineral production was also higher. Iron and steel production advanced strongly but construction was low. It may be of interest to point out that the index of physical volume of business was 125 in 1929; it dropped to 78.7 in 1932; however, in 1933 the index was 79.2. This scarcely indicates the extent to which the falling off in volume of business has been checked. The improvement, however, is evident when it is realized that this index has not been below 82 since last May. The rise in the physical volume of business is perhaps as valuable an index of conditions as is available if a single index is to be taken as a guide. Wholesale prices and volume of business seem to be moving in the same upward direction. Obviously there is a relationship.

Agricultural Products. The index of Canadian farm products was fractionally lower in December, due to a rather sharp decline in the index of field products. Grain prices were generally lower and counterbalanced an advance in the index of animal products.

Agricultural marketings reached a low level in December, the index falling to 30.7. The grain index was 24.7 and the live stock index 57.5. Hog marketings were 69.5 as compared with 88.0 in November.

The index of cold storage holdings was slightly lower in December and little change was registered at the first of January.

With the close of the year confidence in the business outlook was somewhat stronger, and wholesale prices were advancing. Apparently a larger proportion of business concerns are paying dividends than a year ago. Retail business seems to be materially better than a year ago. Cold storage stocks are low indicating that supplies are likely to move more rapidly in the future. These are favourable factors.

ANNUAL AND MONTHLY INDEX NUMBERS OF PRICES AND PRODUCTION
COMPUTED BY DOMINION BUREAU OF STATISTICS

Year	Wholesale Prices 1926 = 100				Retail prices and cost of services (5)	Production (6) 1926 = 100			
	All commodities (1)	Farm products (2)	Field products (3)	Animal products (4)		Physical volume of business	Industrial production	Agricultural marketings	Cold Storage holdings
1913....	64.0	62.6	56.4	77.0	65.4	....	....	....	....
1914....	65.5	69.2	64.9	79.0	66.0	....	....	....	....
1915....	70.4	77.7	76.9	79.2	67.3	....	....	....	....
1916....	84.3	89.7	88.4	92.3	72.5	....	....	....	....
1917....	114.3	130.0	134.3	119.6	85.6	....	....	....	....
1918....	127.4	132.9	132.0	134.7	97.4	....	....	....	....
1919....	134.0	145.5	142.4	152.5	107.2	71.3	65.5	48.1	47.1
1920....	155.9	161.6	166.5	149.9	124.2	75.0	69.9	52.6	94.2
1921....	110.0	102.8	100.3	108.5	109.2	66.5	60.4	65.2	86.4
1922....	97.3	86.7	81.3	99.1	100.0	79.1	76.9	82.6	82.6
1923....	98.0	79.8	73.3	95.1	100.0	85.5	83.8	91.4	87.8
1924....	99.4	87.0	82.6	97.2	98.0	84.6	82.4	102.5	114.6
1925....	102.6	100.4	98.1	105.7	99.3	90.9	89.7	97.2	108.9
1926....	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
1927....	97.7	102.1	99.9	105.7	98.4	106.1	105.6	103.6	110.0
1928....	96.4	100.7	92.6	114.3	98.9	117.3	117.8	146.7	112.8
1929....	95.6	100.8	93.8	112.5	99.9	125.5	127.4	101.1	109.6
1930....	86.6	82.3	70.0	102.9	99.2	109.5	108.0	103.0	128.4
1931....	72.2	56.3	43.6	77.6	89.6	93.5	90.4	99.0	125.7
1932....	66.7	48.4	41.1	60.7	81.4	78.7	74.0	114.3	120.1
1933(7).	67.2	51.0	45.7	60.9	78.0	79.2	76.8	105.1	115.4
Jan.....	63.9	43.6	35.1	57.9	79.1	68.1	62.2	56.1	112.0
Feb.....	63.6	43.0	36.0	54.7	78.4	67.0	60.9	76.5	127.6
Mar.....	64.4	44.7	38.0	56.0	77.8	68.4	62.5	129.0	135.8
April...	65.4	46.8	41.1	56.4	78.1	69.8	65.1	104.1	112.7
May....	66.9	51.2	46.9	58.4	77.0	76.4	72.7	95.4	100.4
June....	67.6	52.6	49.4	57.9	77.0	82.2	79.8	221.9	119.9
July....	70.5	60.1	60.8	59.0	77.2	84.1	82.6	136.3	114.5
Aug.....	69.4	57.0	54.9	60.5	78.6	89.8	89.5	197.2	114.2
Sept....	68.9	54.7	49.5	63.4	78.8	90.8	90.2	101.1	115.7
Oct.....	67.9	51.4	44.6	62.8	77.9	88.2	87.4	70.5	112.7
Nov....	68.7	53.8	46.7	65.8	78.1	85.5	83.9	41.8	111.1
Dec.....	69.0	53.3	45.3	66.6	78.4	86.2	85.1	30.7	107.6

1. See Prices and Price Indexes 1913-1928, pp. 19-21, 270-289 and 1913-1932, p. 15.

2. Wholesale prices of Canada products of farm origin only. See Prices and Price Indexes 1913-1931, p. 33, and Monthly Mimeographs 1932 and 1933.

3. Wholesale prices of grains, fruits and vegetables.

4. Wholesale prices of Animals and Animal Procudts.

5. Including foods, rents, fuel, clothing and sundries, See Prices and Price Indexes 1913-1928, pp. 181-185, 290-293. 1926 = 100.

Prices and Price Indexes 1913-1931, pp. 122, and Monthly Mimeographs 1932-1933.

6. Monthly Review of Business Statistics, pp. 8, and Monthly Indexes of the Physical volume of business in Canada, supplement to the Monthly Review of Business Statistics, November, 1932.

7. Preliminary.

It is noticeable that construction remained at low levels in 1933. This has been an unfavourable factor, but there is now prospect of an advance.

United States. The Agricultural Situation (January 1) published by the Bureau of Agricultural Economics, Washington, D.C., summarizes the situation as follows: "The reports from the various sections of the country may be summed up as reflecting three general facts, as an outcome of the 1933 season: a somewhat better income from the main cash crops, such as cotton, wheat and potatoes; very short crops and relatively high prices of feed grains, with a resulting difficult winter for many feeders in the North and West: distressingly low prices in the beef cattle, hog, dairy, and poultry industries. So far this winter it appears that the crops are better property than the animals."

United Kingdom. The November index of prices of agricultural products was 109 as compared with 107 in October (1911-1913 = 100). The monthly index was 107 in January 1933 and declined until June. Since then, it has been rising steadily and the November index was the high point of the year.

LA SITUATION ECONOMIQUE

PREPARE PAR LA DIVISION DE L'ECONOMIE AGRICOLE DU MINISTERE DE L'AGRICULTURE, OTTAWA, ET BASE SUR LES DONNEES RECUEILLIES PAR LE BUREAU FEDERAL DE LA STATISTIQUE

Les prix de gros au Canada ont continué leur marche ascensionnelle en décembre. L'indice s'est élevé de 68.7 à 69.0. Les animaux et leurs produits, les fibres, les matières textiles et leurs produits, le bois, les produits du bois et le papier, le fer et ses produits, les métaux non ferreux et leurs produits, et les minéraux non métalliques ont enregistré une hausse, tandis que les produits végétaux, les produits chimiques, et les produits de même nature, étaient en baisse. L'indice préliminaire pour 1933 était de 2.2 points plus élevé que celui de 1932: ce qui est encore plus significatif, c'est la persistance avec laquelle cette fermeté s'est manifestée sur les marchés de gros pendant les derniers mois de l'année dernière.

Prix du détail. Répondant à la hausse des prix sur les denrées alimentaires et les vêtements, l'indice des prix du détail qui était à 78.1 en novembre s'est élevé à 78.4 en décembre. Il est à noter sous ce rapport qu'il y a eu en général amélioration dans le commerce du détail pendant les cinq derniers mois de 1933 par comparaison aux mêmes mois en 1932. Ceci indique que la confiance renaît et que le pouvoir d'achat augmente.

Embauchage. La situation du travail continue à s'améliorer. L'indice au 1er janvier 1934 était de 95.0 contre 91.8 au commencement de décembre. Le nombre actuel d'ouvriers employés était un peu moins élevé qu'au 1er décembre, mais la baisse saisonnière habituelle a été beaucoup moins forte que d'habitude, et c'est pourquoi l'indice réglé est plus élevé.

Volume physique des affaires. L'indice du volume physique des affaires, qui était à 85.5 en novembre est passé à 86.2 en décembre. C'est là 13.6 points de plus que l'indice de décembre 1932. La production industrielle était de 17.4 points supérieure à l'indice de décembre 1932. Au cours du dernier mois, l'indice des industries manufacturières s'est relevé de 2.4 points. La production minérale était aussi plus forte. La production du fer et de l'acier a beaucoup augmenté, mais le bâtiment était encore bas. Il est intéressant de noter que l'indice du volume physique des affaires, qui était de 125 en 1929, est tombé à 78.7 en 1932, et remonté à 79.2 en 1933. Ceci n'indique guère cependant jusqu'à quel point la diminution du chiffre des affaires a été enrayée mais le fait que cet indice n'est pas descendu au-dessous de 82 depuis le mois de mai est un signe éloquent d'amélioration. Cette augmentation dans le volume physique des affaires est peut-être le meilleur indice des conditions que l'on puisse trouver, si un seul indice doit servir de guide. Les prix de gros et le volume des affaires paraissent avoir tous deux la même marche ascensionnelle. Il est évident qu'il existe des relations entre les deux.

Produits agricoles. L'indice des produits agricoles canadiens avait baissé d'une fraction en décembre à cause d'une baisse assez prononcée dans l'indice des produits des champs. Les prix du grain étaient en général plus faibles, faisant contre-poids à une hausse dans l'indice des produits animaux.

Les ventes agricoles ont atteint un bas niveau en décembre, l'indice est tombé à 30.7. L'indice du grain était à 24.7 et l'indice des produits animaux à 57.5. Les ventes de porcs étaient à 69.5, contre 88.0 en novembre.

L'indice des produits frigorifiés était légèrement plus bas en décembre et il n'y a eu que peu de changement au 1er janvier.

Vers la fin de l'année, la confiance dans l'industrie paraissait renaître, les prix de gros montaient. Le nombre de maisons de commerce qui paient des dividendes est plus considérable que l'année dernière. Le commerce du détail paraît être dans une bien meilleure situation qu'il y a un an. Les stocks en entrepôts froids sont peu abondants, ce qui indique que les approvisionnements s'écouleront plus rapidement à l'avenir. Ce sont là des facteurs favorables. Il est à noter cependant que le bâtiment est resté à un faible niveau en 1933, et la situation générale en souffre mais l'on prévoit maintenant une amélioration.

Etats-Unis. La situation agricole (1er janvier) publiée par le Bureau de l'économie agricole, Washington, D.C., résume la situation comme suit: "Trois faits généraux, résultant de la saison de 1933, se dégagent des rapports reçus des différentes parties du pays: rendement des principales récoltes pour la vente en nature, comme le coton, le blé et les pommes de terre, un peu plus fort, très faibles récoltes et prix relativement élevés pour les grains à bétail, et hiver pénible pour beaucoup de nourrisseurs du Nord et de l'Ouest; prix d'une faiblesse désespérante pour les industries du boeuf, du porc, de la vache laitière et des volailles. Jusqu'ici cet hiver, il semble que les récoltes sont plus avantageuses que les animaux."

Royaume-Uni. L'indice de novembre des prix des produits agricoles était de 109 contre 107 en octobre (1911-1913 = 100). L'indice mensuel qui était de 107 en janvier 1933 a baissé jusqu'en juin. Il s'est relevé rapidement depuis lors et l'indice de novembre était le point le plus haut de l'année.

RESUME DES ARTICLES PUBLIES EN ANGLAIS DANS CE NUMERO

La situation de l'agriculture dans la vie economique du Canada. T. W. Grindley, Bureau Fédéral de la Statistique, Ottawa, Ont.

L'auteur montre le sérieux de la situation agricole au Canada. Les chiffres qu'il donne démontrent la difficulté et même l'imposibilité qu'il y a à rembourser des dettes contractées avant 1929, commencement de la déflation, avec un revenu qui a été réduit depuis de façon considérable. La réduction des coûts de production et des dépenses courantes constituent le premier pas à faire pour parer à la dépression, mais de telles mesures doivent nécessairement être completées par une liquidation des dettes et une amélioration des prix. Des restrictions sur les saisies seront également utiles. Elles préviendront le désespoir, l'éviction et l'abandonnement en masse des exploitations agricoles.

Il est cependant possible d'accorder trop d'importance aux dangers de la situation actuelle. La position du cultivateur est soumise à des fluctuations soudaines et rapides. Les prix des denrées agricoles sont généralement les premiers à réagir et à remonter après une dépression. Les divers facteurs qui amènent la déflation des revenus comportent généralement leurs propres correctifs. La sévérité des ajustements nécessaires en matière de réduction de dépenses mesure les économies et les bénéfices qui seront réalisés quand les prix commenceront à remonter. La rapidité avec laquelle se terminera la dépression dépendra ainsi de la réduction des dépenses, puisque les prix en hausse deviendront profitables d'autant plus tôt que les dépenses auront été réduites davantage. La fin de la dépression agricole actuelle ne sera pas aussi nette qu'en 1924. Les espérances de la première moitié de 1933 ont été en partie détruites. On avait pris pour la guérison depuis si longtemps attendue ce qui n'était qu'une simple spéculation sur les résultats de la déflation. Une partie de l'avance dans les prix a cependant été retenue. Le mouvement à la hausse peut être erratique, mais il y a des signes indubitables qu'il a réellement commencé.

LES LIVRES

Le premier volume d'une encyclopedie agricole

L'Ecole Supérieure d'Agriculture, Ste. Anne de la Pocatière, a depuis sa fondation en 1859 toujours occupée une place prépondérante dans les destinées agricoles du Canada-français, tant par les mouvements et les politiques d'organisation agricoles qu'elle a dirigés, les programmes d'action qu'elle a conçus, que par ses professeurs qui ont représenté les intérêts des cultivateurs aux Parlements de Québec et d'Ottawa. C'est pour pousser plus loin son travail d'action, envers une vulgarisation et une diffusion encore plus générales de la science agricole, qu'elle a crû devoir assumer la tâche de préparer ce nouveau Manuel d'Agriculture. C'était pour répondre à un besoin urgent et aussi parce que la publication d'un tel volume avait été demandée avec instances, surtout en ces derniers temps.

Tandis qu'en France l'on connait *l'Encyclopédie Agricole* publiée par un comité d'ingénieurs-agronomes, éditée par J. B. Baillière & fils, et qu'aux Etats-Unis, l'on a la *Série des Manuels ruraux* (Rural text-book series) éditée par L. H. Bailey, nous n'avions chez nous aucun travail de similaire importance. Il convenait qu'au Canada-français la publication d'un *Manuel complet d'Agriculture* en trois volumes soit entreprise par la plus ancienne Institution agricole au pays.

En parcourant le tome premier, *Les Champs*, l'on ne tarde pas à se rendre compte qu'un tel volume représente, de la part du groupe de professeurs qui ont collaboré à sa rédaction, une somme de travail considérable, et comme le dit si justement Son Emminence le Cardinal Villeneuve dans sa lettre d'approbation ". . . . . qu'il marque un bel effort du personnel enseignant de notre Ecole d'Agriculture pour diffuser plus largement encore les bienfaits de la science agricole".

Les Champs n'est pas un simple manuel rempli de formules techniques, c'est un traité complet du sol et de la production des récoltes. Rédigé en termes compréhensifs, en phrases claires et consices, pleines de sens et d'enseignement, suffisamment pourvu d'illustrations expliquant les points essentiels du texte, il met successivement sous les yeux du lecteur l'étude du sol, ses qualités, ses défauts, les amendements, les façons culturales etc., etc. Au cours de ses six cent trente pages, ce premier volume expose la relation entre le sol et les plantes et indique les principes généraux d'amélioration. Les maladies des plantes, les insectes et les mauvaises herbes sont tour à tour étudiés et les moyens de protection et de destruction clairement indiqués. C'est avant tout un livre essentiellement pratique, destiné au grand public agricole, aux cultivateurs. "Un dictionnaire d'Agriculture que ce volume *Les Champs*", me disait dernièrement un de mes bons amis-cultivateur, résumant ainsi son appréciation.

C'est l'aide-mémoire réclamé par l'agronome soucieux de pouvoir toujours donner en tout et pour tout une réponse juste et précise. C'est le livre tout désigné pour les curés ruraux, les écoles moyennes d'agriculture, les cours abrégés, les cercles agricoles, les opérateurs de fermes et de champs de démonstration, les cercles de jeunes, les jardins scolaires, etc. Ce devrait être aussi la plus importante partie du bagage d'un colon.

C'est un traité qui offre des suggestions, des méthodes d'amélioration réalisables sans de grands déboursés. C'est un livre au point. On dit que les bons livres font leur chemin. *Les Champs* et les deux volumes qui le suivront iront plus loin; ils feront époque dans notre histoire agricole au Canada-français.

—Georges Gilbert.

NOTES AND NEWS

WHAT IS AGRICULTURE WORTH TO CANADA?

The main theme of most of the oratory and editorial comment produced for rural consumption in Canada is, "the farmer—the backbone of the nation!" Commerce and industry accompany with the chant, "when the farmer is prosperous, business is good." The same idea is to be found in all young and growing countries wherein agricultural expansion on a large scale has taken place during the last century. The United States had achieved what was thought to be prosperity founded on a steadily expanding industrial system, but it has been pointed out by some of those who are responsible for framing the present farm programme that agriculture was on a downward spiral even during the time when the purchasing power of the American public was at its peak. Partly because of the plight of the farmer, the depression is said to be more severe in the United States than in Canada. These things are all "said to be" so, and most of the time we accept such statements as axiomatic. It is well, however, to probe a little deeper. We in Canada are subject to many of the same forces of western civilization which manifest themselves to an advanced degree in the United States. But economic conditions are by no means the same in the two countries.

The position of agriculture in the economic life of Canada is presented in this issue very clearly by Dr. T. W. Grindley of the Dominion Bureau of Statistics. The stabilizing effect of Canadian agriculture on our economic life, and the dependence of Canadian agriculture on world markets are points with which all technical agriculturists should familiarize themselves, and we feel that Dr. Grindley has assembled a portion of the information from the last census in a very comprehensive and useful manner.

C.S.T.A. AND C.S.G.A. CONVENTIONS IN QUEBEC

During the past month plans for holding the annual C.S.T.A. and C.S.G.A. conventions have developed rapidly. A preliminary meeting was held at Macdonald College on January 18th, followed by a meeting with officials of the Quebec Department of Agriculture at Quebec on February 6.

To economize in time and expense, both organizations have reduced the length of their conventions to a minuimm, and have arranged to meet at the same time for certain sessions. It is expected that the Plant Breeders section of the C.S.G.A. will meet on Friday and Saturday, June 22 and 23 at Macdonald College. On Monday, Tuesday, and Wednesday, June 25 to 26, both organizations, along with affiliated groups and societies, will meet at Macdonald College.

An interesting programme is in the process of development. The various groups and societies concerned are planning for two or three half-day sessions of intensive study of their specialties. Programmes for the open sessions of the C.S.T.A. will probably center around the policy of the Society under present conditions, on the present economic situation, and on educational methods in the Province of Quebec.

In connection with the latter subject, a tour of the province has been planned to allow members of the C.S.T.A. to study the various institutions and extension methods now functioning. On Thursday, June 27, the convention will visit the Oka Agricultural Institute at La Trappe, a short distance from Macdonald College. This institution, affiliated with the University of Montreal, is one of the two agricultural colleges in Quebec. Extensive additions have been made to the buildings and equipment since the C.S.G.A. convention was held there in 1926. On Friday, June 28th, the party will leave for Quebec City, stopping at Deschambault in the afternoon. The farm at Deschambault, under the direction of S. J. Chagnon, is a resident vocational institution for farm boys. Hundreds of farm boys have attended this school to learn various farm operations and to take short-courses in various subjects. From Deschambault the party will motor to Quebec for the night, and on Saturday morning

will hold a C.S.T.A. session. Week-end tours will be arranged to historic and scenic spots. A visit to the Agricultural School at Ste. Anne de la Pocatière will be arranged for those driving east, and a tour to points in the Eastern Townships will be arranged for those returning to Ottawa and points west.

Arrangements for both the C.S.T.A. and C.S.G.A. have been placed in the hands of one committee with two vice-chairmen, one to look after each organization. This committee includes representatives from all institutions and organizations involved, but lack of space prevents us from including more than the executive of the general committee and the chairmen of sub-committees.

GENERAL CONVENTION COMMITTEE:

Honorary Chairman:	Hon. Dr. Adelard Godbout, Minister of Agriculture for Quebec and President, C.S.T.A.
Chairman:	J. F. Snell, Acting Dean, Macdonald College.
Associate Chairman:	Rev. Fr. Leopold, Director, Oka Agricultural Institute and Vice-President, C.S.T.A.
Vice-Chairman:	Prof. R. Summerby, Macdonald College, President, C.S.G.A.
" "	Mr. L. H. Hamilton, President, Macdonald College Local, C.S.T.A.
Secretary:	Mr. A. J. G. Maw, Macdonald College, Secretary, Convention Committee.

SUB-COMMITTEES:

Programme:	L. C. Raymond, Chairman
Accommodation:	E. W. Crampton, Chairman
Transportation:	A. R. Ness, Chairman
Entertainment:	W. A. Maw, Chairman
Publicity:	L. C. McOuat, Chairman

NEWS ITEMS

G. Boucher (Laval '33) of Saint-Philippe de Néri, P.Q., is now doing post-graduate work in economics at the Ontario Agricultural College. His address is Department of Economics, Ontario Agricultural College, Guelph, Ont.

C. A. Eaves (McGill '32) formerly of the Horticultural Division, Central Experimental Farm, Ottawa, is taking post-graduate work at Cambridge University. Mr. Eaves was the recipient of a scholarship from the I.O.D.E. and is carrying on work in cold storage of apples.

The sympathy of members of the Society is extended to Dr. H. B. Sommerfeld and his son on the death of Mrs. Sommerfeld at Yorkton, Saskatchewan, on December 20th.

The sympathy of members of the Society is also extended to Professor R. Summerby of Macdonald College on the recent death of his mother.

NEW MEMBERS

The following members have been received since December 1, 1933:

R. D. Bird (Manitoba 1924, B.Sc.), Brandon, Man.
A. J. Boudreau (Laval 1932, B.S.A.), Inverness, N.S.
O. G. Caldwell (Manitoba 1932, B.S.A.), Winnipeg, Man.
C. A. Eaves (McGill 1932, B.S.A.), Cambridge, England.
Ernest Giasson (Laval 1932, B.S.A.), Ste-Martine, P.Q.
P. Lagloire (Montreal 1932, B.A.), Quebec, P.Q.
S. J. MacKinnon (N. S. Agricultural College), Mabou, N.S.
R. J. MacSween (N. S. Agricultural College), Antigonish, N.S.
Maurice Proulx (Laval 1931, B.S.A.), Ithaca, N.Y.
A. Touzain (Laval 1932, B.S.A.), Quebec, P.Q.
T. Uyeda (British Columbia 1933, B.S.A.), Vancouver, B.C.